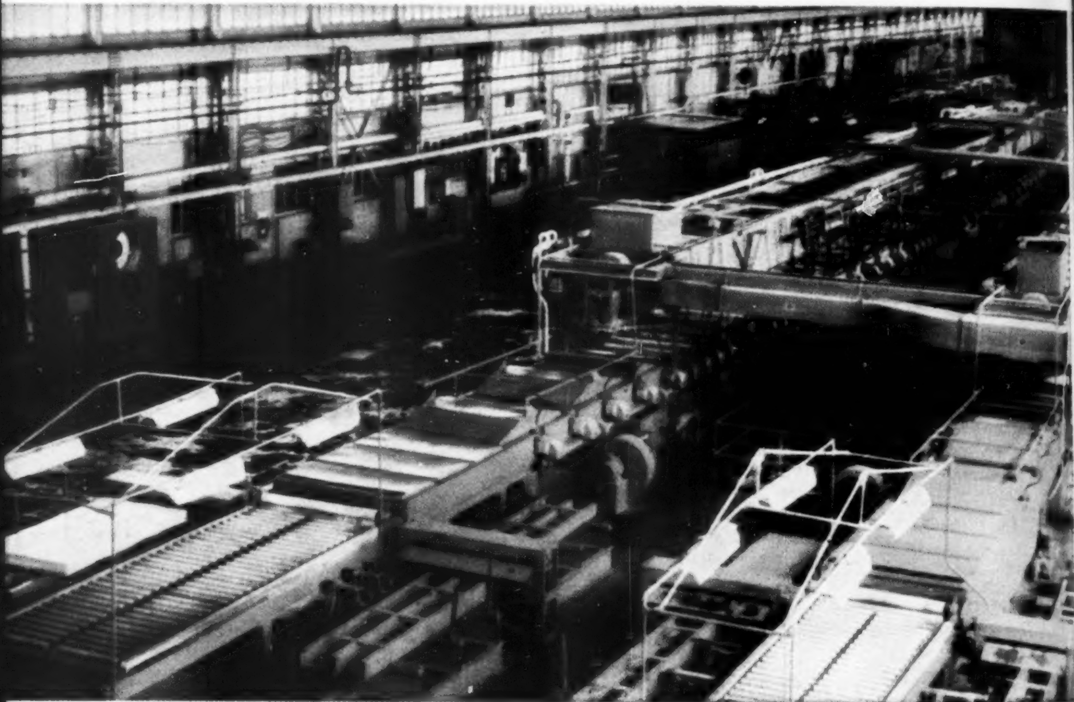
# metal finishing

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

Vol. 2 No. 19 (new series) JULY, 1956



# metal finishing journal

JULY, 1956 AN INDUSTRIAL NEWSPAPERS PUBLICATION Vol. 2, No. 19 (New Series)





*Official Organ of the*

**INSTITUTE OF VITREOUS ENAMELLERS**

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*Chairman:*
H. LAITHWAITE

*Secretary:*
J. D. GARDOM
John Gardom & Co., Ripley, Derby

*Telephone:* Ripley 136

*Published on the 15th day of each month by*

**INDUSTRIAL NEWSPAPERS LIMITED**

Chairman and Managing Director:
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**JOHN ADAM HOUSE**
**17-19 JOHN ADAM STREET**
**ADELPHI, LONDON, W.C.2**

Telephone: TRAfalgar 6171 (P.B.X.)
Telegrams: Zacatecas, Rand, London

*Subscription Terms:*

Home and Overseas 24*s.* per annum prepayable
Single copies 2*s.* (2*s.* 4*d.* *post free*)


**THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.**

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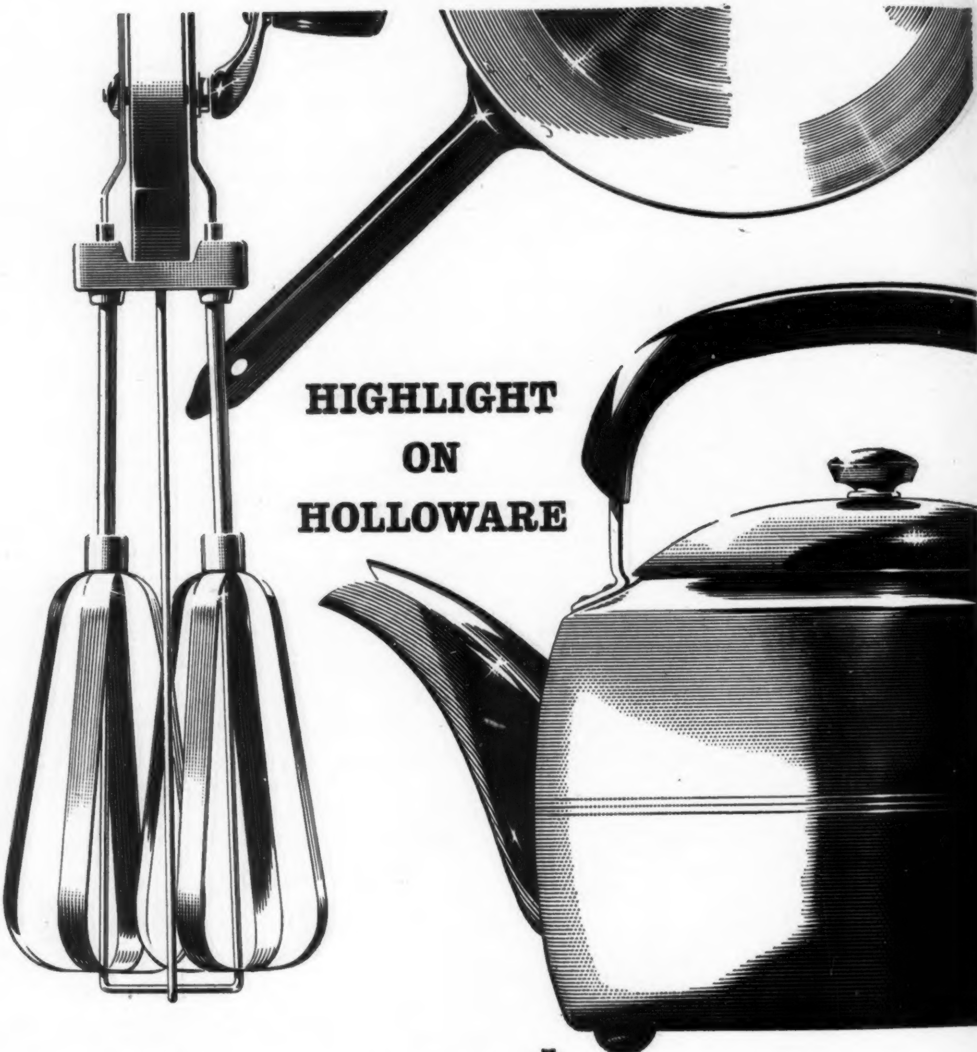

# HIGHLIGHT ON HOLLOWARE

The housewife expects domestic holloware and other kitchen utensils to be bright and attractive. The manufacturer knows, however, that the necessary polishing costs money. A method of reducing these costs is by chemical or electrolytic polishing in solutions based on phosphoric acid. Aluminium, copper alloys and stainless steel, can all be polished by these processes.

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# GALVANIC ACTION

*AS long as man continues to use steel as the principal material from which to fabricate the great majority of commodities in daily use (and there is every indication that he will continue to do so for a very considerable time) so long will it be necessary for him to take measures to prevent attack on the surface of the metal by the atmosphere by which it is surrounded.*

*Existing means of protecting steel surfaces against atmospheric attack are for the most part widely known, although, at the present rate of technical advance, improvements and additions to the available range occur almost daily.*

*The method of protection, which in the broadest sense is by far the most commonly adopted, is the application of a coating, the nature of which may vary greatly, which is tightly adherent to the steel surface and serves as a barrier between it and the corroding influences which surround it. The efficiency with which the steel is protected depends on the extent to which the coating is successful in preventing atmospheric access to it. This is largely a function of how well the coating itself is immune to such attack and also of the degree of porosity or permeability of the coating.*

*Certain coatings which have an excellent inherent resistance to corrosive attack suffer from the disadvantage that unless applied in an uneconomic thickness it is difficult to ensure the absence of pores through which corrosion of the underlying steel can take place. It is a matter of considerable regret that in the present state of our knowledge these circumstances prevail in the case of nickel, although there are indications that the establishment of techniques for the deposition of non-porous nickel may not be too long delayed.*

*Among the metals traditionally used for the protection of steel, one whose claim for attention has a duplex basis, is zinc. Zinc has the merit of being capable of being applied by a wide variety of techniques, including hot dipping, electrodeposition and spraying. It exhibits a very useful degree of resistance to atmospheric corrosion and lends itself to certain chemical surface treatments which can enhance this resistance still further. Moreover it has the further valuable property, which has won for it a special position among corrosion-preventive media, of affording protection to the underlying steel even when the continuity of the zinc coating is interrupted by pores or mechanical damage.*

*A further advantage with which zinc was not endowed by nature, but which it has acquired in this country, to the great benefit of its users, is a Development Association, which has been remarkably successful in promoting the use of zinc in many fields. One of the most notable achievements of the Z.D.A. in recent years has been the initiation of a series of international conferences on hot-dip galvanizing in the organization of which it has played a major part. The present issue of this Journal is wholly devoted to a special report on the proceedings at the fourth of these Conferences held last month in Milan. The number of pages which we accord to this technical report is a measure of our conviction that zinc, whether it be applied by hot dipping or any of the other available or yet to be developed processes, is a metal which is destined to play an increasingly important role in the finishing and protection of steel.*

# Talking Points by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

## ARE WE ALL REDUNDANT?

IT is only about 30 years ago that the word "robot" was coined to describe a mechanical man, and the conception of such a device was a slow-moving automaton with arms and legs capable of carrying out, rather crudely, some of the more simple human movements.

Things have developed so far since then that we now accept as normal the performance of mechanical "robots" which outclasses in speed and accuracy anything that man can do.

On the face of it there would, however, seem to be some fields in which machines would not be at all practical. One of these would appear to be looking up information in published literature. It is therefore with no little surprise that we note that a 200-page book has appeared on "Machine Literature Searching". The chapter headings alone are remarkable, including discussions on such subjects as Operational Criteria for Designing Information Retrieval Systems, and the Encoding of Diagrams.

Any day now, the literature *writing* machine will arrive, and "Platelayer" will be replaced by a few transistors, condensers, and bits of wire. The product will then go automatically into the archives until the literature searching machine digs it out again. What do we all do then?

## MONEY DOWN THE DRAIN

THE problem of disposing of waste liquors and effluent from plating and pickling looms increasingly large. Although local authorities have to be tolerant to some extent in the case of existing plants, they tend to be much less so where new installations are concerned, and many firms are shocked at the cost of dealing with effluents, even from relatively small factories.

It is noteworthy, therefore, that more attention is being given nowadays to the question as to whether many of such effluents might not be reduced in quantity, or at least in toxicity, by changes in processing methods. Sometimes such changes can even result in savings, which will more than compensate for the costs involved in any new equipment which might have to be installed.

A typical example is the way in which waste liquors from sulphuric acid pickling are being regenerated for re-use, while the ferrous sulphate is extracted and converted to a marketable product. The amount of sulphuric acid that has to be discharged is, therefore, reduced, whilst substantial economies in pickling costs are effected at the same time. Something similar has also been done in the case of chromic acid anodizing liquors. The possibilities of this approach in the case of materials such as cyanides are obviously going to be more difficult, but certainly worth exploring.

## DODO-ESQUE

THE world's largest rack-type plating machine is to be installed within the next two years at the Ford Motor Co.'s plant at Monroe, U.S.A., for the chromium plating of the large and complex shaped bumpers with which automobiles are increasingly becoming adorned. This fact cannot nowadays be regarded as surprising nor can some of the details of the dimensions of the plant, which is no less than 750 ft. long, with other statistics in proportion.

What is surprising is the fact that the power supply is provided by 80 motor-generator sets. In this country, plating engineers would no more think of installing motor-generators for such a plant than they would of using Leclanché cells. The mere thought of the maintenance and housing of a power supply of this description when rectifiers are so readily available, would be enough to discourage the idea.

There are certain local conditions and State regulations in the U.S.A. which tend to favour generators as against rectifiers, but one would have thought that these might have been circumvented by now.

## PIPING HOT

ONE of the tricks which nature has played on the chemical engineer is to make some of the most corrosion-resistant materials so brittle that they cannot be used universally. Amongst the most important of these are heat-resisting glass and impervious graphite. Two recent developments may, however, improve the prospects of these products, especially for pipe lines and heat exchangers. The first is a method of wrapping glass tubing in glass-fibre reinforced plastics, which greatly reduces the risk of fracture as a result of mechanical damage. Even if the glass should break, the plastic covering will prevent any leakage for a long time, or even permanently under most circumstances.

The second development is an impervious graphite tube contained in a steel or non-ferrous metal outer sheath; special fittings are provided to ensure continuity of the carbon lining. The system is resistant to hot chlorinated solvents and to hot hydrochloric and hydrofluoric acids. Also, the high thermal conductivity of the graphite may be a real advantage in many cases.

## 4th INTERNATIONAL CONFERENCE ON

# HOT-DIP GALVANIZING

### *MILAN, JUNE 11-13, 1956*

THE fourth in the series of international conferences devoted to the discussion of the theory and practice of hot-dip galvanizing staged biennially since 1950, was held last month in Milan. The attendance once again showed an increase over that of previous years, over two hundred delegates being present, representing fifteen nations in Europe and the U.S.A.

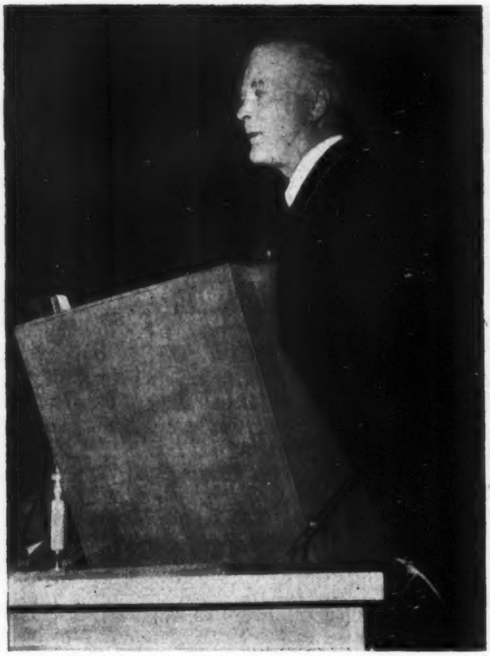
The proceedings were opened on the evening of Sunday, June 10, with an informal cocktail party and reception for delegates and their ladies in the National Museum of Science and Technology, which was the venue for all the technical sessions in the ensuing days.

The following morning at the opening session the delegates were welcomed to Milan by Dr. Ing. Giovanni Rolandi of Societa Montevecchio in the name of the Italian galvanizing industry. Dr. Rolandi referred to the fact that galvanizing had been an industrial process for nearly a century, and in recent years considerable technical progress had been made towards solving many of the problems which the process involved. Much work still remained to be done and he hoped that the present conference would enable further progress to be made towards the solution of their technical problems.

Thanks to Dr. Rolandi for his welcome were expressed by Mr. D. P. C. Neave, chairman of the Zinc Development Association, who also welcomed those attending the Conference. He expressed on their behalf their gratitude to Dr. Rolandi and his staff and the companies associated with them for the excellent arrangements which had been made for staging the conference. Mr. Neave also paid a tribute to Dr. Rolandi's own position in the galvanizing industry, where in addition to being the executive head of an important organization, he had also personally made many valuable contributions to the techniques of zinc production and use.

Mr. Neave went on to say that the most important event which had occurred in the international galvanizing field since the previous conference had been the formation of the European General

*Dr. Ing. G. Rolandi addresses a welcome to the delegates to the Conference at the opening session. He is supported by* (left): *Mr. W. A. Jenkins, president, Hot-Dip Galvanizers' Association and* (right) *Mr. R. L. Stubbs, director, Zinc Development Association.*



*The proceedings of the Conference are opened by a short address from Mr. D. P. C. Neave, Chairman, Zinc Development Association.*

Galvanizers' Association, which had taken a leading part in the organization of the present Conference. He voiced the general regret that its first president, Prof. Dr. Ing. H. Bablik, had been prevented by illness from attending the conference, and the hope that he would be speedily restored to health. They were glad to welcome, however, Dr. R. Haarmann, the chairman of the European Association. Moreover, in the last two years, galvanizing associations had been set-up in Belgium, Denmark and France, so that a large proportion of the countries of Europe now had central organizations through which the galvanizing industry could exchange information.

During the ensuing technical sessions some twelve papers were presented and discussed. Abstracts of these papers are published below, together with a METAL FINISHING JOURNAL report of the discussion upon them. The full text of the papers, together with the official text of the discussion will be published later by the Zinc Development Association.

In addition to the technical programme a number of visits and excursions to places of interest near Milan were arranged for ladies and delegates, as well as visits to a number of works of galvanizing interest.

The Conference concluded with a Banquet attended by a representative of the Mayor of Milan at which Mr. W. A. Jenkins, president of the Hot-Dip Galvanizers' Association took the opportunity of expressing the thanks of the delegates to all those who had contributed to the undoubted success of the Conference.

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## Session I

*Chairman:* Mr. F. CARLSON (President, American Hot Dip Galvanizers' Association)

### "Survey of European Galvanizing Practice in 1955"

By D. N. FAGG (Zinc Development Association)

THE paper is a summary of galvanizing practice in 40 European plants. For comparison, information on four plants in the United States is also included. The survey follows the one made in 1949 of U.K. plants and which was the subject of a paper presented to the First International Galvanizing Conference held in 1950. The present survey, however, is wider in scope and includes information not only on the general working conditions and material utilization—to which attention was confined before—but also on bath heating and productivity.

#### General Working Conditions

Over a quarter of the European plants still galvanize the work with the pickle salts on the surface. In three other plants the work is transferred direct from the pickle tanks to a preflux solution without intermediate washing. Pre-fluxing practice varies widely—in the United Kingdom the triple zinc-ammonium-chloride salt ($ZnCl_2 \cdot 3NH_4Cl$) is preferred, whereas on the Continent varying mixtures of zinc chloride and ammonium chloride are often used. The plants are roughly equally divided between those who heat the solution and those who use it cold.

Similar differences are evident in the galvanizing temperatures. In the U.K. and U.S., temperatures are nearly always below 460° C, but on the Continent much higher temperatures are common, in four cases as high as 480° C.

#### Material Utilization

Marked differences are also found in the amount of zinc used per ton of ware treated, even for plants engaged in similar work. The range was 1·1 to 1·7 cwt. of zinc for plants treating mainly angles, sections and assemblies; 1·9 to 3·0 cwt. for tanks, cylinders and cisterns; and 3·4 to 4·4 cwt. for hollow-ware.

The zinc losses in the residuals were more than one-third of the total zinc consumption for 28 of the European plants and about half for nine of them. In all the American plants the zinc losses were less than one-third.

A comparison of the surface losses from wet and dry galvanizing baths led to the surprising conclusion that

*Chairman of the First Technical Session was Mr. F. M. Carlson, president American Hot-Dip Galvanizers' Association. With him here are* (left): *Mr. W. A. Jenkins and* (right): *Mr. R. W. Bailey.*

wet baths are little if any less wasteful in this respect than dry baths when allowance is made for zinc in the flux skimmings. An analysis of the ash losses for dry baths engaged in similar types of work confirms that most of the ash is formed through disturbances of the bath surface and that the area of the exposed zinc is comparatively unimportant.

Dross losses are too variable for conclusions to be drawn about the advantages of the different galvanizing methods, although in the U.K. plants using the dry process showed the lowest losses.

### Bath Heating

Most baths are fired by modern methods and thermostatically controlled. In Scandinavia electricity is preferred, on the Continent oil, and in the United Kingdom gas and coal (automatic stoker).

The graph of heat consumption against the throughput of work, shows that the amount of heat used in galvanizing a ton of work decreases rapidly as the throughput increases, emphasizing the importance of using a bath to its full capacity.

### Productivity

The main difference between the plants in Europe and America is in output. In only seven European plants are production rates of more than 1 ton per hour achieved. On the other hand, all the American firms have hourly throughputs of well over one ton, in one case reaching the remarkable level of 3 tons 15 cwt. or about 2¼ times more than for the best European plant.

In an attempt to find a better basis for comparison, the ratio of the hourly throughputs to the zinc content of the bath, was calculated. This ratio shows that several smaller plants, with low hourly throughputs are, in fact, operating at a higher degree of efficiency than some of the larger baths with high production rates. It is, however, only a rough indication of the productive efficiency of the different plants and the results must therefore be interpreted carefully.

Mr. D. N. Fagg presenting his paper, said that the fact that a survey of galvanizing practice in Europe had been possible was in itself an indication of the changes which had taken place in the industry in recent years, particularly in the field of technical co-operation. When the previous survey had been presented to the first Conference, in 1950, international co-operation had been in its infancy, and the information available at that time through the Hot Dip Galvanizers' Association had been confined to works within the United Kingdom. Since then there had been a steady movement, stimulated by the International Conferences, towards closer collaboration between the galvanizers of different countries, and last year the European General Galvanizers' Association had been formed. The survey which he presented was one of the first projects organized in conjunction with the new Association. A debt of gratitude was due to the firms who had contributed information and to the various regional organizations through which the information had been collected. A special word of thanks was due to the four members of the American Hot Dip Galvanizers' Association whose contributions provided such an interesting comparison between American and European practice. The main purpose of the paper was to enable galvanizers to compare their own plants with other plants doing similar work, to see whether their operating efficiency could be improved.

### "The Benefits of Applying Work Study to General Galvanizing"

By A. G. NORTHCOTT (Zinc Development Association)

SINCE the formation of the Hot Dip Galvanizers' Association, the U.K. galvanizing industry has shown great interest in improving its technique and productivity.

It took part in several missions to the U.S.A. to study the American industry and, in 1954, with the help of M.S.A. funds, the Z.D.A. set up an industrial engineering section for the industry. The service consists of four parts:

(*a*) Work-study investigations in individual firms.
(*b*) An Advisory Service on specific production and management problems.
(*c*) A series of reports and manuals which will provide a more permanent guide to management.
(*d*) Conferences for managers and supervisors on all aspects of productivity.

Work study has been developed to help cope with the increasing complexity of modern management with its increased emphasis on organization, planning and control. It is usually divided into method study and work measurement and is now used in many industries other than engineering where it was first developed.

The H.D.G.A. had to limit the objectives of its work-study investigations so that as many firms as possible could be visited in the shortest possible time. The main object of the studies was to measure the utilization of the galvanizing bath and of the galvanizing team because the visit to the United States had shown this was a most important factor both in assessing the existing efficiency and in showing where improvements could be made. Ten works have now been visited. The recommendations have covered plant layout and materials handling and have also shown the importance of planning the flow of work to the bath to achieve the best rates of production. Eight of the ten firms have already started work on plans to implement the recommendations. One company now uses half as many men in the galvanizing department and has also reduced the number of workers in other departments.

The efficient use of the bath and the galvanizing team is particularly important as an increase in throughput has a great influence on costs. The investigations revealed disappointingly low bath and team utilizations, but they also showed that very great improvements are possible. The main reason for the low efficiency is probably that most galvanizers do not know the figures for plant and labour utilization because they are very difficult to determine. Various methods are however available for obtaining the figures. In the case of repetitive work, numerous studies of each operation and operator are combined with the figures for shift output and the time lost during a period of a few days. If the work is not repetitive, other methods must be used, the most suitable for the galvanizing industry being "memo-motion study" which is based on the use of a slowed-down cine camera. An alternative is "activity sampling" in which the observer makes a series of tours round the works noting what work is being done.

The H.D.G.A. reports have included many recommendations on plant layout and materials handling. These are both very important as handling forms a large part of the galvanizing operation and works must be properly laid out to achieve continuity of throughput. In one plant a transporter-type crane impeded the flow of work and limited the throughput to a third of what it could have been. Work study is therefore used to plan an improved layout and to decide on the correct equipment. The most useful way of recording the facts is on a "flow process chart".

Unlike some other industries, galvanizing involves only a few relatively unchanging operations so that continued progress in operating efficiency can only be made by studying each of them in detail. A technique called "multiple activity charting" is used to relate the activities of a number of men and machines to each other. A study of this type was made of the operations involved in galvanizing a forty-gallon cistern and as a result the cycle time was reduced by 50 per cent. and the number of workers by 20 per cent. Care must, of course, be taken to ensure that the new method is properly installed and that the workers are not antagonized.

Work study can also be used to help plan incentive schemes. Many existing schemes in the galvanizing industry actually retard improvements rather than encourage them. Schemes should be based on the amount of work involved and not on the output itself, and this can only be determined by work measurement.

The paper has shown how work study is beginning to benefit the U.K. galvanizing industry and also how improvements can be made in the future.

Mr. A. G. Northcott, in presenting his paper, expressed his gratitude to the Hot Dip Galvanizers' Association for the opportunity and privilege of doing so. The first part of the paper, he said, described the formation and operation of the Productivity Service of the Hot Dip Galvanizers' Association. This had been done at the suggestion of the Conference Sub-Committee of the European General Galvanizers' Association, since it would be of particular interest to Continental galvanizers.

In introducing this service, the Hot Dip Galvanizers' Association was well in the forefront of a growing trend in trade association activities. The *Times Review of Industry* for April had pointed out that trade associations were playing a bigger part in work concerned with productivity, and made it clear that in the future associations such as the Hot Dip Galvanizers' Association would accept a greater responsibility in assisting industry and their members to increase their efficiency.

The paper, however, was particularly concerned with work study, which, operated at ts best, was a specialized service to management, helping management to deal with the growing complexity of modern industry. Work study could and did not only improve the methods and conditions for all operations but determine the time which each operation should take to complete. The scope of the subject was brought out in the first chapter of the paper. In the United Kingdom the use of work study was growing rapidly in industry as a whole. Galvanizing had been lagging behind in this development, and therefore there could be no doubt about the wisdom of the Hot Dip Galvanizers' Association and its Productivity Committee in introducing this Productivity Service to its members and concentrating on work study investigations in individual firms. These investigations not only provided specific help to galvanizers, but showed how the various work-study techniques could help them to achieve increased productivity. It was

hoped that the investigations would encourage all galvanizers to initiate or extend the application of work study to galvanizing and ancillary operations.

The primary object of these investigations was to collect facts which could be studied and used as a basis for improvement. As an example, in their most recent investigation it had been recorded that over 11,000 operations were being performed in the galvanizing of one batch of 300 articles and that over five miles was being walked by the operating team. As a result of the study it had been possible to recommend new methods which would reduce the number of operations to 176 and the movement of the operators to just over half mile. It might be thought that that was an exaggerated situation, but he could give the assurance that it was more general than might be imagined.

An important objective in these studies had been to determine utilization figures for the bath, the bath team, and important pieces of equipment. The difficulties of obtaining such information were very real, and one method which had been used, activity sampling, was basically the same as that employed to obtain the information given in Gallup polls. The complete utilization figures obtained in one works by this activity sampling method were shown in the second chart in the paper. The large percentage of delay was a significant factor. The importance of plant layout and materials handling had been emphasized, and most of the reports which had been prepared had included flow diagrams showing the existing, proposed intermediate and proposed long-term layouts for each plant. The work of investigation had given him the impression that much good would result from collaboration between the bath installation engineer and the work-study engineer in the early design stages.

Towards the end of the paper he had emphasized the need for more detailed studies. These were necessary because of the slow rate of change in the galvanizing industry, first in the field of fundamental processes, many of which were the same as they had been 50 years ago, and second, in the design of equipment. Both these facts make it clear that there is a very limited field for effecting improvements in productivity in the galvanizing industry. He believed that to be a very significant fact for the whole industry, and he was sure that more detailed study was the answer. He was also sure that the memo-motion equipment referred to in the paper, which was in fact slow motion photography, could make a very important contribution to improving productive efficiency in galvanizing in the future. He hoped that the application of this memo-motion technique would not be limited to the United Kingdom. They would be very happy to extend it to the Continent.

At the end of the paper there was a list of the steps which it was considered that the industry should take in applying work study in the future. If these were vigorously taken, continuing prosperity for the industry would be assured.

## DISCUSSION

Mr. Ch. van Kempen (Johan Vis & Co. N.V., Amsterdam), said that he was interested in the idea of giving the hourly through ut per ton of zinc. Although Mr. Fagg thought that this might not give an altogether correct comparison, Mr. van Kempen thought that it should give a good idea of the efficiency of the throughput. On the other hand, he would like, if it were possible, to have figures to compare what was produced in a week or a year by the plant. Some figures were given in the paper which related to tons of work done, but it was a question of what sort of work it was. Holloware, of course, required more work than big, heavy articles. He had made a comparison as a very rough guide to obtain records in his own firm by taking the throughput in tons per year, dividing that by ten and adding to it the net amount of zinc used. That gave two factors which provided some idea of what had been produced in different years, and he would like to have Mr. Fagg's comments.

### Monthly Output of Work

Mr. D. N. Fagg pointed out that in the paper he had given the monthly output of work in tons and also he had given the amount of zinc used in galvanizing a ton of work. If he had understood the question correctly, would not those two pieces of information give Mr. van Kempen what he required? Mr. Fagg did not think that the monthly or yearly output mattered very much; the sort of information which was required was how many dips were made per hour, which gave a fair indication of the general working efficiency. He did not think that the monthly tonnage meant very much unless a great deal of information was available about the nature of the work and the facilities which existed and so on. As these varied so widely from one type of plant to another it was possible to compare monthly outputs only in a very general way, and then only for plants which were galvanizing similar types of work. That was why they had tried to introduce the unit of throughput per hour per ton of zinc in the bath. That gave a fairer indication of the relative effort of the different works and was probably as good as anything likely to be obtained from a questionnaire of the type which had been used. The real answer to the question of productive efficiency was to be found by carrying out a fairly long-term programme of work-study investigation in the plant; anything short of that could be only a very rough approximation.

The same limitations, he thought, applied to the amount of zinc used per ton of steel galvanized as to the monthly output. It was necessary to make many reservations and to bear in mind that it was going to vary primarily with the gauge of the material being treated, so that its value was limited to a comparison of plants which were galvanizing almost exactly the same type of work.

### Continental Galvanizing Temperatures

Mr. K. Lewus (Wirtz and Co., Gelsenkirchen, Germany), expressed great interest in the question raised by Mr. Fagg's paper and said that he had been surprised to read in the paper, however, that while in Britain and America the galvanizing temperature was fairly low, the same conservative attitude was not evident on the Continent. That seemed particularly surprising, because the galvanizing temperature in Germany did not usually go above 450° C and sometimes was about 10° C lower. Possibly the information in the paper was not based on a large number of plants, and it was necessary to be wary about giving information which might be a little one-sided. He understood that the information given had been submitted by the various countries, but it would be useful if the various Galvanizing Associations would assemble data for further study.

Some of the other points made in the paper must be accepted with a certain reserve; for example, with regard to dry or wet galvanizing there were certainly other problems involved. There was a question of terminology involved here, and it would be advisable to decide on a better terminology before going any further.

Mr. J. Bradbury (Incandescent Heat Co. Ltd.) congratulated both authors on their papers, which he regarded as very valuable contributions to the galvanizing industry. There might, he said, be differences of opinion about the information which they contained, but he thought that the general picture was one of which careful note must be taken and which must be given careful consideration after the Conference was over.

He thought that there must be a mistake in Table IV of Mr. Fagg's paper, where for plant No. 36 the heat used per ton of work processed was given as $0{\cdot}4 \times 10^6$ B.Th.U. This figure of 400,000 B.Th.U. was extremely low, lower than anything that Mr. Bradbury had ever seen before, nor did he think that it was in fact capable of attainment. This low figure of 0·4 was in contrast with a figure of 0·8 for a plant which was galvanizing about five times the quantity, doing window-frame galvanizing and using town gas with automatic temperature control and no doubt with combustion equipment which would give the maximum combustion efficiency. It had always been known that to fire with fuel oil, as in the case of plant No. 36, was not quite so efficient as to fire with town gas, because of necessity there must be a certain amount of free oxygen in the flue products. He would like to know whether Mr. Fagg had any further information on that subject, because it was of great interest.

### Productivity of American Plants

In Mr. Northcott's paper, which was outstanding, one fact was not brought out. Reference was made to the productivity of the American plants being high in relation to the European plants. The question of fuel application was not referred to in detail, but they had found on several plants recently installed that where automaticity of combustion was provided, and the men on the plant were concerned with galvanizing only, and had not to bother about maintaining the right temperature, dealing with the ashes and so on, production went up and bath utilization was greatly increased.

Dr. R. Haarmann (Siegener A.G., Geisweid, Germany) said he felt that Mr. Fagg had perhaps in his paper made use of data relating to specific types of process, perhaps those dealing with small parts, where low temperatures might be sufficient to give satisfactory results, whereas when dealing with larger articles a higher temperature was required. There might be differences between various countries because the requirements might differ. The size of the installation would have an effect on bath temperature and productivity. He agreed with Mr. Fagg that production had to be considered not only from the point of view o productivity, but also from that of hourly production. He did not know which was the best method to use in order to make comparisons, and he thought that that was a question which might well be investigated further. The hourly production of a plant should, he thought, be related to the number of parts which were dipped. The average weight of an iron part would, of course, give a figure between the two extreme limits for small and large articles. The figures might profitably be studied further, and the European Association might take on this work and try to standardize criteria to be adopted in working out averages. It would be better to start with the bigger companies.

Mr. Ch. van Kempen intervened to say, with reference to a comment made by Mr. Bradbury, that plant No. 36 was one of his and the figure commented on had been supplied by his works manager, who had made a mistake. The figure should therefore not be accepted.

Mr. R. W. Bailey (Zinc Development Association) said that he had had the task at the Copenhagen Conference of presenting a similar review to that which Mr. Fagg had given on the present

occasion. His task had been much lighter than Mr. Fagg's, because he had had only 20 plants to compare and they had all been in the United Kingdom, so that there had been no risk of anything that he said precipitating an international crisis. There were two interesting points of comparison between the survey at Copenhagen and the survey at Milan: productivity, and zinc efficiency.

On productivity Mr. Bailey would echo the sentiments of previous speakers, that it was difficult to find a basis, but there was one basis common to both papers, namely the output of the bath per hour per ton of zinc in the bath. In referring to this he proposed to use Mr. Fagg's rather awkward English unit of the cwt., which might be confusing to those from the Continent, but he did so because delegates would have in front of them Table X of Mr. Fagg's paper, where it was shown that the throughput ranged from 6 to 100 units per hour per ton of zinc in the bath. At Copenhagen the range reported had been from 5 to 132, so that at least one of the plants surveyed there had, on that basis, a higher productivity than anything which had been found in the present survey. The average of the figures in the Copenhagen survey had been 21, and seemed to have risen to 26 in the present survey. Taking into account the many new plants which had been built, and the fact that galvanizers now used larger baths than they did six years ago, he thought it could be said that the rise in output divided by the tonnage of zinc was very satisfactory.

### Zinc Efficiency of Plants

So far as zinc efficiency was concerned, the picture was even better. Mr. Fagg had pointed out that 70 per cent. of his plants were losing one-third of their zinc in residuals. At the time of the Copenhagen survey, 80 per cent. of the plants had been losing one-third in residuals. Mr. Fagg found that 20 per cent. of his plants were losing about half of their zinc in residuals, whereas at Copenhagen 40 per cent. of the plants, or nearly half those surveyed, lost half or more than half of their total zinc in residuals. Those figures reflected an improvement. Although too much emphasis must not be put on zinc efficiency, because it was obviously easier for a galvanizer dealing with thin work to get high zinc efficiency than for one dealing with heavy work, it did form a useful basis of comparison and one which showed up the plants with the higher productivity.

Mr. F. C. BRABY (Fredk. Braby and Co. Ltd.) said that he had not been able to compare Mr. Fagg's paper with that given by Mr. Bailey at Copenhagen, nor with his own details; it might be recalled that he had given some figures at a later Conference. Not having had an opportunity to make such comparisons, he wondered whether the percentages to which Mr. Bailey had just referred

*A contribution to the discussion is made by Mr. F. C. Braby.*

were quite fair. It was well known that averages and percentages could be extremely misleading. What it was necessary to do was to take some of the plants which had sent in figures to both surveys and see whether or not in such cases there had been any improvement. It might be that some of the less-efficient plants, finding that they compared rather unfavourably with others on the last occasion, had not sent in any figures on the present occasion. That would affect the average very much.

Reference had already been made to the difficulty of making broad generalizations with regard, for instance, to the heat used per ton of material. It became more difficult the more widely the sources of information were spread, and he supported very heartily the suggestion that they should try to work out a common basis of measurement

Turning to Mr. Northcott's paper, he would like to say that the members of the Hot Dip Galvanizers' Association in the United Kingdom felt that they had been very fortunate in securing Mr. Northcott's services to carry out the work described. As a representative of one of the firms whose works Mr. Northcott had visited, Mr. Braby said they felt that they had been very fortunate and that Mr. Northcott had given them a great deal to think about. They had a modern plant, recently installed, which they had regarded as fairly efficient, but they now knew the difference. They had a very great deal to learn as a result of what he had told them. They were still studying the report which he had made and hoped to obtain some good results from it.

The greatest difficulty which they experienced, and which was no doubt common to others, was on the labour side. It was all very well to say that by rearrangement of the work it was possible to

get much greater efficiency, but, though it might mean less physical effort, to the men themselves, it meant an alteration in their practice and in the work which they did, and there was a small amount of opposition in consequence which had to be overcome. Men who were used to working in a certain way did not like to change it. Mr. Braby was sure, however, that the necessary changes could be made, and he was most grateful to Mr. Northcott, as no doubt other firms were also.

As Chairman of the Productivity Committee of the Hot Dip Galvanizers' Association, Mr. Braby wished to say on their behalf that they hoped that Mr. Northcott's paper and the work which he had been able to do in the United Kingdom would be of great interest to those from other countries, and that they would find it possible in their own national Associations to do something similar. In the United Kingdom they had had the advantage of M.S.A. funds to a limited extent for two years, but they had to continue themselves thereafter. He hoped that they would be able to do so with continuing success.

Mr. J. Derrider (Travail Mécanique de la Tôle, S.A., Brussels) said that frequently it had been found that in order to cope with conditions which might arise from time to time, galvanizers were obliged to provide a bath of greater capacity than was needed for most of their work and to have a bath of larger dimensions than would otherwise be necessary. Where that was the case, the figures would be completely misleading and the production figures would not reflect the true situation. The tonnage in the bath was not, in his view, a good figure to take. In order to assess productivity it was very desirable to decide on a unit which would allow proper comparisons to be made. This was an urgent question, and the Conference should take it up and try to do something about it. It was obvious from the paper that the range of articles to be galvanized was very wide and it was impossible to apply an average to them; they could be of so many different kinds. It was not possible to make true comparisons until some reliable yardstick had been chosen.

Mr. A. G. Northcott said that Mr. Fagg's figures were useful to the industry only in the absence of more reliable figures. There was a very great need for more detailed information to be made available to the industry as a whole. On the other hand, he agreed with the remark made earlier, that too much must not be read into these figures. He believed that it was necessary to go into galvanizing works and carry out utilization studies. He was prepared to lay himself open to criticism by asserting quite confidently that no general galvanizer knew what his utilization really was, because it was extremely difficult to determine. Wherever there was a team on non-repetitive work the task of determining utilization was very difficult, and that was why he had used some of the newer techniques in trying to determine it. The fact that this information was not available at present made it all the more important that it should be in the future, and he suggested that investigation studies should be made in members' works.

He would like to mention an example of the misleading picture which could be obtained from such figures. One study had been carried out in a works in the United Kingdom which on the face of the overall figures gave the impression that it was the most efficient in the country. It had an output of well over 200 tons a week from one bath. It was found, however, when determining the utilization that the bath was being utilized for only just over 30 per cent. of the time and that the labour force was being utilized for under 50 per cent. of the time. It was found—and an example was given in his paper—that the average dipping time was 12 min. 19 sec., but the actual galvanizing dipping time was 4 min. 5 sec., and therefore only one dip was taking place where it was possible for three to take place. He suggested, therefore, that it was necessary to tread warily and not read too much into these overall figures. They were valuable, however, in giving a comparison between firms doing similar work and in providing a stimulus to obtain more information. He agreed that the necessity for some standard measure was very evident. Facts and information were the basis of improved productivity.

Mr. D. N. Fagg thanked Mr. van Kempen for accepting the responsibility for the mistake with regard to the oil-fired bath in plant No. 36, Table IV, to which Mr. Bradbury had called attention.

### Bath Temperature

He had been very interested to have the comments of Mr. Lewus and Dr. Haarmann on the question of bath temperature. He had pointed out in the introduction to the paper that the survey was in no way representative of the industry throughout Europe. He had only had contributions from 32 different firms, covering 40 plants, and that was only a very small percentage of the total in the whole of Europe. The conclusions which were drawn were necessarily based on the data which had been given, so that there was obviously a great deal of scope for misrepresentation when that fact was borne in mind. He regretted it, but in the circumstances it had been unavoidable. He supported the suggestion that the European General Galvanizers' Association might apply itself to getting more reliable data over a far wider field than had been covered on the present occasion.

He also supported most heartily the point which

had been made about establishing a standard procedure for recording information. As he had mentioned earlier, it had been hoped to obtain information from the different contributors about the weight of material that they were galvanizing at a time. Unfortunately, very few people could give that information, because the work which they were doing was far too mixed and heterogeneous to make this possible. The answer to that was not likely to be very simple in the case of general galvanizing plant; it required a great deal of recording to establish a fair average value for the weight of material per dip in a general galvanizing plant.

He thanked those speakers who had expressed their opinion about the unit of throughput per ton of zinc. He was very conscious of its limitations, but he had felt that it was the best that could be devised on the information available. He did not suggest, however, that it was any sort of substitute for a determination of productive efficiency by work study. It obviously was not. There again, there was scope for further work to be done by the European General Galvanizers' Association.

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## Session II

*Chairman:* Mr. C. ORIGONI (Origoni and C. Metalli)

### "The Painting of Hot-dip Galvanized Steel"

By J. F. H. van EIJNSBERGEN (Stichting Doelmatig Verzinken, The Hague)

GALVANIZED steel does not normally need painting, but if it is exposed to continuous attack by chemicals in a heavily-contaminated industrial atmosphere, painting will considerably extend the corrosion-free life. Painting may also be needed for aesthetic or military reasons. The surface condition of the galvanized steel is important. A suitable surface for painting can be obtained by natural weathering which may take anything from a few weeks to a full year. Alternatively an artificial surface preparation may be used. If the paint selected will adhere directly to galvanizing, degreasing only is necessary. Otherwise a pre-treatment such as wire brushing, shot-blasting, or chemical etching is needed. Chemical-etch treatments give good results, but must be carefully controlled and all residues washed off. Phosphating in a bath at 85° to 98° C followed by careful rinsing is most satisfactory.

Etch primers combine the functions of surface treatment and primer. They generally consist of polyvinylbutyral, chromates and phosphoric acid, but not all types adhere to zinc surfaces. They need no additional primer.

The best paint system consists of two or three top coats. No conventional primer is necessary and in fact lead pigments may cause local corrosion. Only a few special paints will adhere directly to the galvanized surface. These are generally based on polymethanes, copolymers of vinylchloride and vinylisobutylether, amino resins, polymethacrylates or silicone- or ethoxyline-resins, but calcium plumbate pigmented paints have also given satisfactory results. If one of these is not being used, a suitable primer or pre-treatment should be chosen and

*Mr. C. Origoni presides at the second technical session, while Mr. A. Ash is seen here making a contribution to the discussion.*

the top coat selected for the environment. Hydrophylic paints should not be used. The top coat must have both vehicle and pigment resistant to atmosphere in question, but other factors such as ease of application and cost will also affect the choice.

After some years of exposure, a galvanized coating generally needs reconditioning and treatment with zinc-rich paints has been found very satisfactory. Other paints may be applied over zinc-rich paint so long as the solvents do not cause swelling. In sea water there may be some trouble with blistering, but this can usually be overcome by applying a suitable sealing coat.

Ing. J. F. H. van EIJNSBERGEN in presenting his paper, said that there were two points which he would like to emphasize. The first was the approach from the side of the galvanizer. Usually it would not be necessary to paint galvanized steel, because galvanized structures outside in the atmosphere would last from 20 to 40 years; but, due to the amphoteric character of zinc, there was a possibility that in a heavily polluted industrial atmosphere a zinc coating by itself would not give protection for more than 12 years. Moreover, with costly materials and high labour costs it would be increasingly necessary to consider long-term corrosion protection. That was where zinc came in, and had done so for many years; but in heavily polluted industrial atmospheres there was a possibility, by coating the zinc with chemically resistant material, to increase the life markedly to 15 to 20 years.

The second approach was from the point of view of the paint. It was very difficult to paint steel structures. He had seen many specifications in different European countries which prescribed sand-blasting or pickling of the steel to get rid of the oxides. It was well known, however, that it was not always possible to get rid of the oxides, and a simple hand-cleaning method by wire brushes and so on was not sufficient to allow good corr sion protection to be obtained. Dr. Hudson, of B.I.S.R.A., had stated that if iron and steel structures were painted and the basis was not 100 per

cent. sound, one could only expect to get 50 per cent., and in the majority of cases 25 to 30 per cent., of the durability of the paint system.

That was where hot-dip galvanizing came in, and in Holland an extension of the market for it in that direction had been seen. More and more people were becoming aware that the hot-dip galvanizing of steel not only offered very good protection in itself, but also, if it was desired to paint the structure for aesthetic or other reasons, it would take the paint very well. In his paper he had given a list of suitable paints to employ on zinc if the surface was treated with a suitable wash primer. He had not given the proprietary names, but gave the paint vehicle. His Institute intended to publish, in the autumn, a booklet giving the paint systems to apply on hot-dip galvanized steel.

On the other hand, it was not difficult today to paint hot dip galvanized steel. He had often heard it said, "If you are going to galvanize steel you cannot paint it", but fortunately progress in the paint industry today had gone far enough to offer a fairly wide range of possibilities. Mr. Hall, at the Oxford Conference, had given an excellent survey of the position. There were now at least 20 different paint systems which had been worked out which would give good adhesion, adhesion being one of the properties which gave the greatest difficulty.

(The author then showed a large number of colour photographs of painted hot-dip galvanized steel taken at the weathering station of the Dutch Institute.)

## DISCUSSION

Mr. W. L. Hall (General Galvanizers Ltd.) said that he noticed that much more attention was now being paid to, and interest taken in, the subject, which he thought would become of increasing importance to the galvanizing industry in the years to come. To manufacturers who were making large quantities of a product which was galvanized and then painted, the detailed information on paints given in the paper would be of great importance and value. To large users of galvanized steel who required painting to be done on galvanized articles of a similar type, again the paper would be extremely valuable. On the other hand, speaking as a general galvanizer, and basing his experience on conditions in England at the present time, he thought that one was more likely to be asked to give advice to a customer on how to paint just one or two articles. For most of the customer's requirements the galvanized finish would be all that was required, but for some special reason he might wish to paint just one or two of the products that were normally galvanized for him.

It was for that reason that in the United Kingdom considerable attention had been given to the calcium-plumbate paints, because it seemed that no special preparation of the surface was required. They could be applied to a galvanized finish without any etching and without even the use of a wash primer. He wondered whether the author could say what were the possibilities of developing a paint which could be applied simply to a few galvanized articles, without surface preparation, by means of a spray process. Very many people were interested in the spraying of paints, and they were concerned about whether the plumbate paints were suitable for spraying, both from the technical point of view and also from the medical point of view, because of their lead content. Any information about a paint which was suitable for application in that way to a few articles would help a great deal in advising a customer who merely wanted to paint one or two articles.

Mr. A. Ash (Fredk. Braby and Co. Ltd.) said that reference had been made in the paper to the good adhesion to freshly galvanized steel of paints based on calcium plumbate in a linseed-oil vehicle. The Technical Committee of the Hot Dip Galvanizers' Association had been interested in this paint for some time and had exposed a number of samples at the works of several member firms.

Where red lead in linseed oil gave an acid paint film of $p$H 4·0 to 4·5, calcium plumbate, which hydrolyzed in water to give a strongly alkaline reaction of $p$H 12 to 13, had the effect of neutralizing the linseed oil, giving a neutral paint film of $p$H 6·8. It had been stated that the neutral character of the paint film, and its consequent low tendency to zinc-soap formation, might account for its excellent adhesion to zinc, but some a kaline etching effect from the calcium-plumbate pigment might also be a possible explanation.

A firm manufacturing this class of paint had exposed in a semi-rural atmosphere in the United Kingdom a series of tests. An inspection of these samples in July, 1955, showed good adhesion on 24-gauge galvanized sheet first exposed in 1949. Freshly galvanized samples, weathered samples and samples which had received various pretreatments, such as chromating and phosphating, had been coated with a paint based on calcium plumbate. A white-lead finishing paint completed the system. After two-years' exposure the weathered and freshly galvanized samples showed excellent adhesion. The other samples, which had been given pretreatments, were less satisfactory, except for one particular two-pack etch primer based on zinc chromate in polyvinyl butyral medium containing phosphoric acid.

The ability of this class of material to adhere to freshly galvanized material without acid etching was welcomed in the industry, because the practice of using acid etchants left a great deal to the human element, which could not always be relied upon without proper supervision.

### Guarantee For Paint Life Wanted

Mr. P. Morisset (Chambre Syndicale des Fabricants de Tôles Galvanisés, Paris) said that the paper and the author's samples were excellent. Undoubtedly new applications would be developed in the industry following this type of research, and particularly in the building industry. This, however, would create some new problems, because in certain building industries there was always a demand for a guarantee, and in France a guarantee of ten years was wanted for the life of this type of paint.

The author stated that if the surface of galvanized objects became rusted to the extent of 5 per cent. or more, reconditioning should be done as soon as possible. Was that a standard which was generally acceptable or which would be considered satisfactory or should further investigations be made?

In dealing with these painted galvanized surfaces, in the building trade in particular, what quality or level was to be taken as being satisfactory? If a surface was rusted to the extent of 5 per cent., was that to be considered satisfactory, or should anything more be done about it? Was it to be taken that if 5 per cent. was exceeded the surface must be completely stripped and reconditioned and painted again? The discussion of this point so as to allow a standard and yardstick to be set up would be very profitable.

Ing. J. F. H. van Eijnsbergen, in reply, expressed his gratitude for the contributions made by Mr. Hall, Mr. Ash and Mr. Morisset. In reply to Mr. Hall, calcium-plumbate paint would seem to be a very good paint to apply in the near future, but it should be emphasized that it was not possible to apply a paint which used linseed oil as a vehicle in a very heavily polluted industrial atmosphere. Mr. Ash had referred specifically to panels exposed in a semi-rural atmosphere. So far as experience in Holland was concerned, and so far as Mr. van Eijnsbergen had read reports on this remarkable paint, which gave both cathodic and anodic protection to the steel, it might be assumed that it would behave very well in semi-rural atmospheres where there was not too high an attack; but from his experience of linseed-oil paints generally and of stand-oil paints exposed in very industrial atmospheres, he would utter a word of caution about their use in such circumstances. He had exposed the samples which Mr. Bailey had given him last year on the Dutch Institute's rack, but there had not yet been time to arrive at a final judgment on their performance.

The second question put to him was whether or not it was possible to apply to one, two or three hot-dip galvanized articles a spray-paint system which did not need any etching or wash primer as pretreatment. The answer was that that was possible, and he had on view outside the hall a panel on which that had been done. The panel had been coated without etching or wash primer, using a nitrocellulose lacquer combined with some urea resins. The combination of nitrocellulose and internally plasticized urea resins gave a good spraying lacquer which could be applied to the article without any treatment except, of course, degreasing. Every galvanizer would be inclined to say "When an article comes out of my bath there is no grease on it", but as soon as it was handled some grease was put on it by the fingers, and so some slight degreasing action would be necessary to clean the surface.

The second type of paint which could be applied directly to hot-dip galvanized surfaces consisted of paint based on certain vinyl resins, co-polymers of vinyl chlorides and acrylic resins. It was difficult to say for every kind of article what to apply, but any delegate who had a problem on this point was invited to write to the Dutch Galvanizing Institute, who would try to recommend a suitable sound paint system.

Mr. Ash gave a survey of the calcium-plumbate paints. There was no doubt that they would have a great future, especially because they gave cathodic protection in addition to anodic protection. It should still be emphasized, however, that if users who received hot-dip galvanized articles left them lying about before painting, they were likely to have difficulties with the painting. Sometimes painters did not like to use special paints, and at times there may be none of the special paint available. There were advantages, therefore, in the use of a modern wash primer. There were now wash primers which could be bought in one container, with no need for extra mixing, and which were stable and could be put on hot-dip galvanized steel and afterwards almost any type of paint could be applied. Apart from very special paints based on oxidized rubber, bituminous paints and nitrocellulose paints, all the normal paints could be applied when a stable wash primer of this type was used, so that there was the possibility of using very special paints on the surface, of using calcium-plumbate paints, or of applying a wash primer together with almost any other paint.

Replying to Mr. Morisset, the author said that tests had shown that more than 5 per cent. of rust could not be allowed, but he agreed that it was very difficult to establish whether the percentage was 5 or 6. The best thing to do, therefore, was to have a very thorough preparation of the surface and use a zinc dust paint with 94 to 95 per cent. of zinc dust content. It was very important, particularly where there were small holes and the rust might go deep, to clean the surface properly and to use zinc dust paint. The other question, of a guarantee, was also related to the preparation of the surface, because without a properly prepared

*The hair at the third technical session was taken by Dr. R. Haarmann, chairman, European General Galvanizers' Association seen here addressing the meeting.*

surface no guarantee of durability could be offered and a corrosion-proof paint must be used; but the best plan was to use hot-dip galvanizing, which gave the very best base.

## Session III

*Chairman:* Dr. R. HAARMANN (Siegener A.G. für Eisenkonstruktion Bruckenbau und Verzinkerei and Chairman of the Gemeinschaftausschuss Verzinken)

### "The Heating Output and Heat Consumption of Galvanizing Baths"

By Dr.-Ing. B. WUBBENHORST (Verein Deutscher Eisenhüttenleute, Düsseldorf)

THE design of heating installations for galvanizing is largely dictated by metallurgical considerations. The heating must be designed for a low and narrow temperature range between 445° and 460° C both to obtain uniform coatings and to avoid attack on steel pots. There are four methods of heating.

(1) Fuel or resistance heated iron pots.
(2) Cover heated refractory baths.
(3) Direct heating by the heat remaining in the article to be galvanized.
(4) Electrical induction heating.

The costs of the fuels used for galvanizing baths vary greatly, but other factors such as flexibility and cleanliness also influence the choice of fuel. Fuel-oil firing has been increasingly adopted in recent years. The types of oil differ principally in their viscosity, the most satisfactory being fuel oil "L" which does not need preheating either for transport or combustion. Electrical heating is still rare in Germany because of its cost, and in spite of its high heating efficiency, 2 kWh need to cost little more than 1 cu.m. of town gas before it can be competitive.

The heat balance of a galvanizing bath may be expressed as:

$$Q\ \text{total} = \frac{Q\ \text{effective} + Q\ \text{insulation}}{\eta f}$$

where $\eta f$ is the efficiency.

After the introduction of town gas supplies, attempts were made to convert conventional baths to gas firing, and satisfactory installations have now been developed. Waste gas circulation which has also been used for galvanizing baths, provides a very flexible and economic method of heating. Temperature regulation is important, but is almost impossible if the bath setting holds too much heat, or the pot is too small. A good design can achieve almost constant bath temperature with changing loads, although the flue temperature will vary. Output and heat consumption are closely connected in galvanizing baths, the high radiation losses involving a considerable consumption during stand-by times.

Cover heated baths give good figures for heat consumption and metal losses. There is unfortunately little data available on ash losses, which are important in determining the overall efficiency of a bath. Lead-jacketed galvanizing baths have been developed which give uniform heating with long pot life, but they are expensive and are only used for comparatively small installations.

### "Electrical Resistance Heating"

By R. GLOOR (A.G. Rummler und Matter, Däniken, Switzerland)

THIS paper is not concerned with technical details of electrical resistance heating, but only in its comparison with other heating methods. The information is based on a Swiss plant whose present electrical baths formerly used coal heating. Most plants in Switzerland have long since introduced electric heating and in this plant it has been used for more than 20 years. Immediate advantages are that no fuel has to be stored, that cleaner and safer working conditions and better temperature regulations can be achieved.

The control gear for the bath gives individual switching for many heating circuits and a duplicate power input to avoid, as far as possible, interruptions due to electrical faults. Reserve heating costs are distributed uniformly along the bath.

The galvanizing bath is only 12 cm. above the floor, the low height allowing easier handling of the work. The pot, which is of Armco iron, was made with considerable extra height in its centre so that its surface remained plane when it was installed. The heating coils are arranged so that they can be removed individually for easy maintenance.

A mould pit for molten zinc is provided below the ground and in the event of failure the zinc runs straight into it. The pit, which is connected to all five of the baths in the works, is also used when the pit is emptied for inspection and renewal, so avoiding the need for reserve baths and allowing a new pot to be installed in three or four days. An alarm is also fitted so that immediate warning is given if any zinc runs out.

The decisive factor in the economic working of electrically heated baths is the price of current. It should, however, be borne in mind that maintenance costs are lower than any other types of fuel, the temperature can be maintained more accurately, which gives longer pot life and lower dross formation. The initial investment cost is, however, considerably higher.

Mr. R. GLOOR (A. G. Kummler and Matter, Däniken, Switzerland), in presenting his paper, said that the situation in Switzerland was peculiar in that no source of fuel was available, so that it

had been natural to develop the use of electric power; but in other countries, even those which had fuel available, it would be found that the electrical resistance heating system offered many advantages which might well lead to the consideration of the further development of this type of heating for galvanizing baths. In particular, electrical heating could very advantageously be used for medium- and small-size galvanizing baths, and its simplicity might well lead to very serious consideration being given to its adoption.

### "Galvanizing Baths Heated by Gas Immersion Heaters in Lead Pockets"

By L. F. CHAMBERS (G. A. Harvey and Co. (London) Ltd.)

A BATH heated by gas immersion heaters in lead pockets was in commission from March, 1950, until September, 1955, when it was emptied and shut down for inspection. It was thermostatically controlled and insulated covers were used during standby periods. During the period under review, the working or operational time was 53¼ per cent. of the total hours under melt.

The amount of gas used during the initial period of heating up and experimental work involving modifications to burners was 1,170 therms. For the 282 weeks of production, when 9,205 tons were galvanized, the total gas consumption was 137,204 therms, an average of 14·9 therms per ton galvanized.

For the years 1952 to 1955 inclusive, the heat balance was as follows:

| | | |
|---|---|---|
| Total zinc to bath (melted) | 843·3 | tons |
| Total output | 6559 | tons |
| Total gas consumption | 96081 | therms |
| Total hours | 32424 | |
| Total shift hours | 17157 | |
| Total stand-by hours | 15267 | |

(Includes four annual holiday periods of two weeks duration.)

The average pick-up over the whole period was 8·3 per cent. and the average operating temperature 450° C. Gas consumption was equivalent to 14·65 therms per ton. The net gas consumption was 8·006 therms per ton galvanized and at 70 per cent. efficiency, the gross was 11·44 therms. Thus the stand-by consumption was 14·65 to 11·44 therms, *i.e.*, 3·21 therms per ton galvanized.

The radiation losses from the bath surface were 1,725 B.Th.U. per sq. ft. per hour.

In August, 1955, severe corrosion to the top edges of the bath, caused by flux, was discovered. Before repairing the damage, the bath walls were thoroughly examined and measurements of the thickness taken with an ultrasonic gauge. The maximum loss of thickness—at one point only—was 0·345 in. which suggests that the ultimate life before penetration might be 20 years.

Mr. L. F. CHAMBERS (G. A. Harvey and Co. (London) Ltd.) introducing his paper, said that it was an answer to a request for information on the performance of a bath. He had not set out to show how the bath was made or operated, but had given figures of actual experience of galvanizing a very varied range of products over the life of the bath. When he said "the life of the bath", he should add that the bath was now working again, and it was hoped that its life would be very much longer than the 5½ years which had been recorded. Mr. Eatwell, the managing director of Mr. Chambers' firm, had been responsible for the design and inception of the prototype bath in 1947, and was a co-patentee with the company of this type of bath. The bath had been installed in a new plant in 1950, and a day-to-day record of output and gas consumption had been consistently kept over the whole period of commissioning. In May, 1951, when a new incentive bonus scheme had been started, the number of pieces galvanized and the weight began to be recorded, and it was from those records that the performance was summarized.

On the question of showing performance in terms of average figures, the piece-weight had varied from 1¼ lb. to 97½ lb. per piece. That showed the weakness of the use of averages, which he himself had done, so that he was as much to blame as anyone else, in trying to arrive at a performance figure for galvanizing baths. He agreed with what had been said in the discussion on Mr. Fagg's able paper the previous day, that there should be some internationally-agreed method of measuring performance. He was not prepared to say what that should be or what lines it should take, but when average figures were used the result did not necessarily mean exactly what it said.

Mr. Gloor had dealt with the electrical heating of galvanizing baths. Mr. Chambers had considered this for the particular type of bath which h himself had described, but they were not in the fortunate position of having cheap electricity available and they found that the cost ratio of electricity against gas would be 3/1. Certain advantages due to the higher efficiency of electrical heating would reduce that ratio to about 2⅓/1, but it was still much too high from an economic point of view.

In the report recently published by Mr. Northcott on his visit to America, a good deal was said about lead-jacketed baths. Mr. Chambers had not been fortunate enough to see these baths in action, but he hoped that in the ensuing discussion Mr. Northcott would give some further information about them.

(This session was preceded by the showing of a film entitled, "Zinc Controls Corrosion". Mr. E. V. GENT (U.S.A.), in introducing the film, which had been made by the American Zinc Institute, said that it began by recalling the tremendous cost of steel corrosion and reviewed briefly the various methods of protection which were available. Of these, zinc was shown to be the most effective, because of its excellent resistance to atmospheric corrosion and because it protected the steel electrochemically. The film illustrated methods of

treatment and showed examples of corrosion prevention by the use of zinc, including the protection of the hull of the new American atomic reactor submarine. Copies of the film, he said, were available in England and Holland and had been ordered for France and Germany.)

## DISCUSSION

Mr. J. Bradbury (Incandescent Heat Co. Ltd.) said that Dr. Wubbenhorst's paper contained a wealth of information on the efficiencies which could be expected from various types of heating applied to galvanizing baths. It was a great pleasure, he said, to find that in Germany the recirculation system was finding great favour, because it might be recalled that at the first Galvanizing Conference, at Copenhagen, he had mentioned that the company with which he was associated was very deeply interested in that system. It had been used many years not only for heating galvanizing baths, but for many other purposes. Where low temperatures were concerned and rapid heat application was necessary it was considered to be the best system obtainable.

For galvanizing baths, however, it was necessary to consider not only the question of rapid heat application, but also in many cases the efficiency of the operation in terms of productive time. Some galvanizers were operating their baths on a single-shift system and others on a two-shift system. The heat losses in the non-productive period could form an appreciable percentage of the total heat required for the galvanizing operation. The use of special types of refractory insulation brick, to the exclusion of the general refractory bricks, was to be recommended. They had low thermal capacity and were quite capable of standing up for very long periods against the temperatures associated with galvanizing bath settings.

As indicated in Dr. Wubbenhorst's paper, there were two types of recirculation system, the inductive type and the fan-recirculation type. The former was cheaper in terms of initial outlay, but in his experience the efficiency was considerably lower than with fan recirculation, since it was impossible to achieve the necessary velocities in the settings which were conducive to rapid heat transfer at very low temperatures. It was important that the passages round the back should be narrow, to give a scrubbing action on the side of the bath, which usually gave better heat transfer because it broke down the inert film on the side of the bath and allowed the heat to penetrate rapidly.

With the induced type of recirculation there were many developments in progress, and later he would like to refer to a particular new application which was a reply to the question of economics in respect of the use of electricity, but before doing so he wished to refer to Table II in Dr. Wubbenhorst's paper, which dealt with the merits of the various fuels, with particular reference to fuel oil.

The use of fuel oil was growing, and a large amount of development work had been done with regard to burner equipment, controls and so on. He thought it was correct to say that fuel oil, properly used, was equally as controllable, equally as efficient, and generally as clean as gaseous fuels. The main reasons for criticism were due to the fact that the installations were not done properly; they were usually an attempt to convert an old job rather than to have one properly constructed for the purpose. The use of heavy fuel oil was quite simple. The paper suggested that it was impracticable to preheat in galvanizing plant, but on several recent installations where oil firing had been adopted they had arranged for the heavy fuel oil to be preheated in the main storage tanks to about 70° C. The oil was pumped round the ring-main system and the final preheating was done by a line heater adjacent to the burner equipment, so that there was very little loss of heat and the viscosity was maintained right up to the point of combustion. Temperatures as high as 135° C were used for the final preheat, and it was found that the combustion was very satisfactory indeed. All the fuel supply lines were insulated to prevent any heat loss during transmission from the main source.

### Designs for Recirculation Heating

Reverting to the designs for recirculation heating, by fan in particular, to which Dr. Wubbenhorst referred, he had been concerned with the development of similar types of unit for several years, and he had decided, Mr. Bradbury thought with advantage, to dissociate the combustion of the fuel from the galvanizing bath itself. By that he meant that they did not burn the fuel adjacent to the bath; it was burned in a separate combustion chamber, and there they could use a single burner or two burners, whichever was preferable. In quite a few installations they used a single burner, with a standby burner calibrated for the heat requirements of the bath during the standby periods. The connexion between the heater battery and the galvanizing bath was by well-insulated flues, and the heat loss was only a fractional percentage of the total heat which was dissipated by various other losses. It was an advantage to have two separate units, each of which could be simple in design and easily controlled; and if there was a run-out at any time the main portion of the heating system was not spoilt by liquid zinc from the bath.

With regard to the use of electricity, there would be general agreement that electricity offered what was probably the ideal medium for heating galvanizing baths if it could be bought at a low enough price. There had been many attempts to simulate

the use of electricity by fuel-fired installations for galvanizing baths. The well-known radiant wall type of unit was a particular example, and they had heard of radiant heaters, tubes and so on, which had been used in America. At the present time there was available a new system of radiant heating known as the jet tube. This was an alloy-steel tube in various forms, which made use of the principle which was utilized in the inductive type of equipment illustrated by Dr. Wubbenhorst and which induced the recirculation of the products of combustion. At the moment it was used extensively for critical heat-treatment processes, but it would not be long before there were galvanizing baths operating with this system. With this system it had been possible to simulate as nearly as possible, and certainly ahead of anything previously known, the heating conditions which applied with electrical elements.

He had been particularly interested to read the paper by Mr. Chambers, and considered the performance of the bath there described to be extremely good. He would like to point out, however, that if with a bath the sides of which were originally $1\frac{1}{4}$ in. in thickness, there was wasted away in $5\frac{1}{2}$ years 0·345 in. of that thickness, the physical strength of the bath must be seriously impaired, and if the wastage was continued it was not possible to calculate the ultimate life of the bath before penetration merely by the metal wastage on the side walls.

In conclusion, reverting to Dr. Wubbenhorst's paper, Mr. Bradbury wished to mention a practical point which he had found to be of great assistance in running continuously operating galvanizing baths in which large tonnages were processed. The normal drossing of a pot was done by dropping the dross from the bottom of the pot, but he would emphasize the necessity of drossing the sides and ends of the pot or wherever the heat was applied regularly in the same way. Dross was a heat insulator, and if there was the build-up of a heat insulator on the inside of the pot, the temperature on the outside must build up if the same amount of heat was to be transmitted. Values as low as 150 kilo/cal. were quite normal for continuous bath operation.

### Economic Aspects of Heating Systems

Mr. K. Lewus (Wirtz and Co., Gelsenkirchen, Germany), dealing with the economic aspects of heating systems in relation to the insulation of the pots, said he had found that by insulating the sides of the galvanizing bath great savings of fuel or power could be achieved, and a considerable saving could be made by insulating the bottom of the bath also. He had provided a gas channel along the bottom of the bath, not merely with the intention of heating the bath but in order to provide a small amount of heat which would be sufficient to prevent the actual dissipation of heat. In that way the efficiency of the bath had been increased from 40 to 50 per cent. He assumed that the average figure for a large bath would be two tons per hour and for a small bath about one ton per hour. The addition of a small amount of heat at the bottom certainly prevented heat dissipation.

Mr. Van Der Vrande (Holland) referred to one point in the paper by Dr. Wubbenhorst, with which he did not agree. In Table IV of the paper it was stated that the bath radiation losses with a bare bath surface were much higher than with an ash-covered bath surface. His experience was that with a bare bath surface one could put one's hand only a few millimetres from the surface without feeling any heat, but where there was an ash-covered surface one could burn one's hand at a distance of 30 to 40 cm. from the surface. It might be found beneficial, he suggested, to bare the bath surface during the week-end to lower the radiation losses when there was no work in the bath.

Mr. E. M. Wilson (Henry Hope and Sons Ltd.) referring to the paper by Dr. Wubbenhorst, said that many people present would be operating on a smaller scale than some of the typical German examples which had been given, and it might be of interest to refer to a few practical points regarding the operation of plants which had been in use for some time. It had already been said that very little information was available with regard to the life of pots, and as the subject of a paper for a future Conference, that was a suggestion which might well be followed up. The Technical Committee had tried to obtain information on the subject, but had found that so far the records had not been sufficiently well kept to enable this to be done. If they were to start now, however, it should be possible to prepare a very interesting paper by the time of the next Conference.

He would like to mention that after they had had an accident with a bath which had brought the temperature up to 600° C in a period of about 26 hours, they had still been able to cool that bath off and remove about 40 tons of dross and put the bath into operation again without serious difficulty. After the bath had operated for another two years the thickness of the plate which was left was measured and compared with the thickness measured immediately after the accident.

In two-years' production after the accident, 13,500 tons were galvanized with the formation of 129 tons of dross. The bath-plate erosion, measured all over the surface and averaged out, came to 13·6 cwt. of steel, the equivalent of 17 tons of dross, so that out of the total dross formation in the two years of 129 tons, 17 tons had been formed from the bath itself, which was 0·855 per cent. on the output of the bath or 11·8 per cent. of the zinc used.

He had been very interested in Mr. Chambers' photograph of the ends of the bath after such a long period of use, because of the extremely uniform surface.

As there had been so much discussion of recirculating systems, he would like to mention that with a recirculating system fired by coal and automatically controlled, so that the products of combustion from the separate combustion chamber were taken from the top flues round the sides and back to the starting-point, unless the fly ash was screened so that it could not go round the system, the scouring effect when there was a change in direction of the flue gases was most serious; so that while these recirculating systems had certain advantages with gaseous fuel, they were definitely dangerous with solid fuel unless that precaution was taken. With regard to the use of oil firing for a similar system, if there was high carbonization, as sometimes happened due to ineffective operation of burners for a short period, the insulating effect of the carbon deposit could be very serious, and once it had formed it was very difficult to remove it.

Mr. F. N. HODGETTS (Stordy Engineering Ltd.) referred to the good effect of well-insulated settings and said that the provision of a flue under the bath for the exhaust gases, while the idea seemed to horrify some galvanizers, had proved in no way detrimental.

### Advanced Design Recirculation Systems

A considerable advance had been made in recirculation system designs. He had in mind a bath with a throughput of six tons per hour, where an even and safe distribution temperature was maintained in the flue, and also a coal-fired plant which, when modernized, led to the coal consumption falling by a half, while so far as production time was concerned one shift had been discontinued with no drop in the weekly output.

With regard to oil firing, which was becoming in great demand, it was necessary to maintain the fuel/air ratio over the complete range of the burner capacity. Where only the atomizing air was supplied to the burners the necessary control could be provided by an automatically controlled damper which worked in sympathy with the instruments and in parallel with the control valve. Where the air for both atomization and combustion was supplied to the burners, the burners must be of a fully proportioning type, and not only must the volume be maintained constant, but also the pressure, as required by the burner manufacturers. To maintain this, the design of the blower fan which supplied air to the burner must also be investigated with regard to its volume and pressure characteristics.

Mr. J. N. PARK (Thompson Bros. (Bilston) Ltd.), dealing with the question of recirculation, said that to some extent he agreed with Mr. Wilson on this subject. He was not at all convinced that recirculation was the answer. There was evidence that recirculation, due to the increased speed of the gases, caused over-heating, particularly on corners and where one flue passed another flue, and failures had occurred.

The type of plant of which he had experience was the radiant type, fired either by coal gas or by oil. It was possible to decide what was the best type of plant only after the plant had been installed for many years. The question which was asked by most galvanizers was "How long wil the bath last?" and most of them would like a guarantee. There was evidence that plants of the type in question were lasting five, six and seven years, and they were still in operation.

Oil firing was coming into its own and investigations were being carried out into the subject on a considerable scale. He had fired baths by heavy oil in Brazil which were working satisfactorily and had been in operation for two years. It was probably too early to say at the moment just what the life of oil plants would be, but it was hoped that it would be in the region of that for coal-fired plants, since the design was similar; all that had been altered was the fuel.

Dr. Ing. B. WUBBENHORST, replying to the discussion, expressed his pleasure that his paper had given rise to so lively a discussion, but felt that some of his remarks had not been understood. In referring to the loss of 110 kg. he had been referring to optimum conditions, but his paper made it clear how essential it was to consider the economic point of view. Naturally in Germany, they were also building galvanizing baths operating with forced circulation. In all countries he thought it would be agreed that the comparison betwen electric and gas heating would be in the ratio of about 2/1, 2 kW corresponding to about one cubic metre of gas.

With regard to heavy oil, there was no experience available in Germany, where only light oil was used. This was a new departure, whereas in England a great number of baths were heavy-oil or diesel-oil fired, and he was very pleased to know that there had been so much technical progress with this method of firing. It was necessary to preheat up to 80 to 100° C, and this involved installation costs and a phase lag between the heating point of the fuel and the heating point of the bath. A comparison would, he thought, prove that heavy oil never gave such satisfactory burning performance as a gas oil, though it had other economic advantages.

Opinion in Germany also was very much divided on the subject of recirculation, because the way in which heat dissipation took place had not been completely elucidated. One point which had to

be considered with recirculation systems was that there might be a temperature drop while the gas was carried over to the bath. He was certainly of opinion that when building this type of bath a complete heating chamber should be provided beneath the bath. The provision of two separate units made it easier to carry out maintenance, but he thought that the solid block construction was on the whole to be preferred.

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## Session IV

*Chairman:* Mr. R. STEWART (Chairman, Technical Committee Hot Dip Galvanizers' Association)

## "Galvanizing Pot Construction"

By L. F. CHAMBERS, G. R. FAULKS and W. A. JENKINS

THIS paper is a report prepared by the Technical Committee of the Hot Dip Galvanizers' Association to guide the galvanizer in his choice of plant. No attempt has therefore been made to go into great detail or to interfere with the aspects which are the bath manufacturers' responsibility.

### Size

The choice of pot size depends on the type and amount of work to be galvanized. The surface shape is fixed by the size of the work and the other dimensions by the need to provide adequate heating. The heat requirements of a bath can be calculated by taking into account the heat losses by radiation, the heat needed to bring work to galvanizing temperature and that required for melting the zinc. With this information the minimum depth needed to provide an adequate area can be calculated, assuming that the amount of heat put through the walls is limited to 7,000 B.Th.U. per hour per sq. ft. Clearly a deep bath with a small surface area will be most satisfactory. Four practical examples are as follows:

(*a*) $5 \times 3 \times 3$ ft. 6 in. deep. Capacity approximately 8 tons of zinc, giving an average throughput of about $\frac{1}{4}$ ton per hour—suitable for small work.

(*b*) $10 \times 4 \times 4$ ft. 6 in. deep. Capacity approximately 35 tons of zinc, giving an average throughput of about $\frac{3}{4}$ tons per hour—used for general work.

(*c*) $13 \times 5 \times 9$ ft. deep. Capacity approximately 110 tons of zinc, giving a throughput of 2-2$\frac{1}{2}$ tons per hour—suitable for window frames.

(*d*) $30 \times 4 \times 5$ ft. deep. Capacity approximately 110 tons of zinc, giving a throughput of up to 6 tons per hour—suitable for long structural sections.

### Material

The steel used for pot construction should contain not more than the following:

| | |
|---|---|
| Carbon | 0·15 per cent. |
| Silicon | 0·07 per cent. |
| Manganese | 0·60 per cent. |
| Sulphur | 0·05 per cent. |
| Phosphorus | 0·05 per cent. |

### Plate Thickness

The plate chosen for the pot will have to be thick enough both to support the weight of the zinc and also to give an adequate life. Since the setting generally costs more than the pot, a fairly thick plate is advantageous. The following plate thicknesses are recommended for the four examples quoted above: for bath (*a*) 1$\frac{1}{2}$ in. sides and 1 in. bottom; bath (*b*) 1$\frac{1}{2}$ in. side and 1$\frac{1}{4}$ in. bottom; baths (*c*) and (*d*) 2 in. sides and 1$\frac{1}{2}$ in. bottom.

### Construction

The most satisfactory arrangement is given by a three-plate construction comprising two plates bent to form the sides and half ends and one bottom plate. Radiussed corners of radius not less than 6 in. should be used.

### Fabrication

The welds are very important in pot construction and close attention must be paid to welding technique, steps being taken to ensure good preparation and root penetration from both sides. A suitable basic electrode with deoxidizing characteristics should be used. The end seams may be butt welded and left proud or the join may be covered by a butt strap.

### Stiffeners

Stiffeners may be needed to prevent buckling in large, deep baths.

### Stress Relieving

Stress relieving is important as residual stresses may accelerate attack by molten zinc. The normal technique for heavy welded structures may be used.

Mr. G. R. FAULKS (Hot Dip Galvanizers' Association), who presented the first paper, said that probably the major overhead cost in the operation of a galvanizing plant was failure of the pot itself. In submitting the paper, it was the desire of the Hot Dip Galvanizers' Association of the United Kingdom to focus attention on the fabrication of the galvanizing pot. This had always been regarded as a specialist product, outside the control of the galvanizing works. With coke-fired pots and the difficulty of ensuring uniform heating, in the past the working life of the galvanizing pot had been accepted as being of short duration. A new pot could be readily installed and the cost of rebuilding the setting had not been high. Modern plants, however, used gas, oil or electric heating, with large masses of refractory, which enabled the pot to be operated under close temperature control. It became imperative, therefore, to obtain as long a life as possible from the pot, owing to the very much higher cost of replacement.

With that object in view, it had been thought desirable to state briefly some of the more important points which the galvanizer with a modern plant should consider. Obviously the first item to be considered was the composition of the steel used in the fabrication of the pot. They were fortunate in the United Kingdom in being able to obtain a first-class product. Their Association was co-

operating with the British Standards Institution, who would shortly be publishing a British Standard specification for galvanizing pots.

So far as heating was concerned, the size of the pot controlled this, as had already been stated. The paper on bath heating and operation given at Düsseldorf in 1952 had covered the subject very thoroughly, and Dr. Wubbenhorst in his most interesting paper that morning had also dealt with it. The present authors' observations were made only to draw attention again to this problem, to which there were still many different solutions, according to the size of the product and the throughput which the galvanizer wished to obtain. It was obvious that the size of the product to be galvanized had first to be decided, and that controlled the size of the pot, but the throughput also affected the matter. According to whether 16-gauge pans or ships anchors were being galvanized, a different heat input would be required.

The heat losses in the operation of the galvanizing plant were very severe. From the formula given in the paper, it was clear that it was more economical to use a deep bath with a small surface area if the type of product to be galvanized would permit this to be done, but unfortunately that rarely happened. The authors believed that the total heat losses might be as high as two-thirds of the total heat, leaving only one-third available for the work, if an economic throughput was to be obtained.

They considered that the joining of the steel plate by efficient welding techniques was of even more importance than the actual thickness of the plate. As stated in the paper, weld metal composition was important. The suggested composition of the pot steel and the weld metal was shown, and the difference in the silicon and manganese contents should be noted. The silicon had a strong influence in resisting scaling. Both the silicon and the manganese were lower in the plate steel than in the weld metal.

Also shown was a section through the bottom of a galvanizing pot where it had been joined to the side wall. The pot failed after five years. The defect was almost continuous along both side walls. It would be seen that some form of surface penetration had been made on the under-side, extending to a depth of 1½ in. The inside fillet weld had been insufficient to withstand the strains imposed either during fabrication or during service conditions. The cracking which commenced in the weld allowed the zinc to penetrate and fill the unfused zone at the base of the main outside welded joint. The line of the fracture followed the heat-affected zone in the plate material, where some measure of grain growth would have taken place during the welding operation.

As a result of the work which had been done, the authors hoped to obtain much longer pot life. They did not see why the life, at present usually taken as five to seven years, should not be increased to as much as 20 years. That should lead to an increased amount of work for hot dip galvanizers, because the reduced overhead costs would reduce the price. The wastage of steel due to rust would be reduced, and, as was well-known, steel was in short supply throughout the world.

On behalf of the sub-committee, he would like to thank the staff of the Hot Dip Galvanizers' Association for the data used in compiling the paper.

## "The Influence of Impurities in Iron on Attack by Molten Zinc"

By Dr. D. HORSTMANN (Max Planck Institute)

THE rapid attack which galvanizing pots sometimes suffer is often due to impurities present in the iron or steel. The present investigations were made at the Max Planck Institute, Düsseldorf, to fill in some of the gaps in knowledge of the effects of carbon, silicon, manganese, phosphorus, sulphur, aluminium and copper. Forty-two different steels were made up, each series containing different quantities of the element under examination, others being excluded as far as possible. The attack was measured by immersing the test-pieces in molten zinc at various temperatures for various times and determining the loss in weight of iron by the difference in weight before the test and after stripping the galvanized coatings. For experimental convenience, the course of the attack was followed by using time-independent parameters.

The rate of attack on pure iron decreases parabolically with time up to 495° C and above 515° C, but between these temperatures attack proceeds at a high and constant rate. From 475° to 495°, and 515° to 530° C attack is also enhanced, but still decreases parabolically with time. In general, the same pattern is observed when impurities are present, but the temperature limits are shifted. The region of undiminishing attack corresponds to the formation of non-adherent alloy layers most of which crack off and float away, whereas at higher and lower temperatures adherent layers are formed through which further attack proceeds by a diffusion mechanism obeying the usual parabolic law. The rate of total attack is then controlled by diffusion through the Gamma-layer.

The impurities present in commercial iron not only alter the rates of attack, but also extend the range of increased attack. As lamellar pearlite, 0·9 per cent. carbon gives a range of 480° to 525° C, but at 2 per cent. carbon the range contracts again to 495° to 515° C. Globular pearlite behaves similarly except that the widening is maintained at higher contents. Carbon as troostite has little effect. Silicon in small amounts causes the lower limit of enhanced attack to fall. With increasing manganese-content the temperature range of enhanced attack diminishes and disappears completely at about 2·5 to 3 per cent. manganese. Beyond 5 per cent., however, severe attack reappears and at 8 per cent. extends over the whole range investigated; at these concentrations the basic material is no longer ferritic.

Phosphorus, sulphur, aluminium and copper all reduce

the lower limit of the range of enhanced attack without affecting the upper limit.

The impurities all have an influence on the rate of increased parabolic attack occurring at either end of the linear range, but the magnitude of these effects depends on the temperature. With increasing contents of carbon (except as troostite), silicon, manganese and aluminium, parabolic attack first increases then diminishes. Phosphorus, sulphur and copper cause increases only—high phosphorus contents are particularly harmful—but in the quantities in which they are present in commercial iron, their effect is insignificant.

The rate of linear attack in the increased range also depends on the impurity content in much the same way for carbon, silicon, phosphorus, sulphur, copper and aluminium. Manganese has a different effect in this region, first reducing the rate of attack and raising the temperature of maximum attack (510° C at 1·69 per cent. manganese). Additional manganese leads to a sharply increased rate, however, presumably because of the change to a martensitic structure.

For practical purposes it is evident that high contents of carbon and silicon should be avoided in pot steel. Phosphorus is also harmful in high concentrations, but is not important up to the 0·08 per cent. generally present in commercial steels. Ordinary quantities of manganese are also without effect, but it remains to be seen whether benefit could be derived from greater amounts.

Dr. D. Horstmann (Max-Planck Institute for Iron Research, Düsseldorf) summarized the contents of his paper and emphasized the need to use alloys which did not intensify the zinc attack.

## DISCUSSION

Dr. M. L. Hughes (B.I.S.R.A.) said that Dr. Horstmann's subject was a large one, full of surprises and difficulties and therefore not easy to condense into a short paper suitable for the Conference. There would be general agreement, however, that he had made an excellent job of it and had presented a paper which was compact and had a practical bias, which was what was needed. His success would be appreciated when it was remembered that in the last English edition of his well-known book Dr. Bablik took just over 50 pages to deal with the importance of the composition and condition of the steel base in galvanizing, and then proceeded to take just over 50 pages more to explain how the results in the first part were affected by the composition of the bath. Dr. Hughes realized that Dr. Horstmann was not concerned with the composition of the zinc, but the galvanizer had to bear these things in mind, and many other factors in addition. Dr. Horstmann pointed out that steel containing 1 to 1½ per cent. silicon produced alloy at a fantastic rate, so that it was important to remember that if the bath contained 0·05 per cent. of aluminium such steel might produce no alloy at all, the action of aluminium being accentuated in steels of that type. That, however, might be a digression.

Dr. Horstmann had succeeded admirably in the paper in doing what he set out to do. Having paid him that sincere compliment, Dr. Hughes hoped that he would be patient with him if he went on to make a few remarks which might appear to be somewhat critical. Some of them might also appear to be trivial; if so, he had two excuses. One was that it was desirable for the paper in its final form to be free from any errors, and the other was that he had once been a teacher, and if he saw the smallest error he automatically reached for a blue pencil. He proposed to deal with the trivial points first.

The paper was not easy to read. The secret of the author's success had probably been that he had limited the text to seven pages and had provided a mass of diagrams, which it would take a long time to appreciate. The paper was therefore full of "meat", but it was necessary to study the excellent diagrams to find it. It was a pity, therefore, that the author had put a stumbling-block in the reader's way by giving photomicrographs with no indication of the magnification. Dr. Hughes believed that they were × 200, because he had seen some of the work reproduced elsewhere, but a metallurgist on seeing a microstructure wanted to know how thick was the coating, and in this paper there was no magnification to tell him.

His last trivial item was that Fig. 7 contained so much information condensed into very small diagrams that he had to put on his glasses to read it.

### Relative Merits of Killed Steel and Rimming Steel for Galvanizing.

Coming to wider issues, the author had condensed his paper partly by throwing many things overboard. He did not say anything about the casting conditions of the steel, for instance. That he had killed the first lot with aluminium could be seen from his Table. He did not give any details of his dipping procedure. It might be thought that those particulars were not necessary in a paper of this kind, but Dr. Hughes would justify his point about the casting conditions because the presence of 0·05 per cent. of silicon in steel might have a much greater effect than just the silicon; it might have the effect of turning a rimming steel into a killed steel, or a balanced steel as it was called in the steel trade. Rimming steel was very good for galvanizing, and the outer surface, from the rimming action in the mould, might be purer than Armco iron from the point of view of carbon, with about 0·04 per cent. carbon on the surface, which might be ½ in. thick on the original ingot. Recently he had been concerned in a discussion about the behaviour of two steels 0·2 in. thick. One galvanized successfully with a 0·005 to 0·006 in. coating, while the other, which had almost the same analysis, had a poor coating of 0·012 in. That had been traced ultimately to the casting conditions; the

good plates were rimming and the bad plates were killed.

Dr. Hughes knew that Dr. Horstmann's dipping conditions were satisfactory because he had read about them elsewhere, but on reading the paper one might wonder, because well-known research workers had written papers in which they stated that it was not possible to galvanize in a matter of seconds. They put samples in and drew them out minutes later without any coating at all. Looking through the paper there did not appear to be any reference to fluxing, but Dr. Horstmann must have fluxed because he referred to the vapour of ammonium chloride. It might be as well, however, to mention the fact.

### Effect of Silicon

Dr. Hughes said that from the paper and many others silicon would seem to be the galvanizer's chief enemy, a terrible element which should not be in the steel at all. On the other hand, at Copenhagen, killed steel with 0·1 per cent. silicon had been suggested, and it had been said that steel for galvanizing pots should be specified as killed with a li tle silicon. Silicon was not such a terrible enemy if the time of immersion was very short, as in wire galvanizing, because the effect of silicon would not be felt very much in 10 to 15 seconds. The choice of compositions mentioned in the paper was less useful to the galvanizer than if results had been given for 0·02, 0·04, 0·08 and 0·15 per cent. silicon, because those were the silicon contents which were of interest in day-to-day galvanizing.

### Calculation of Iron Loss

Dr. Horstmann had calculated the iron loss by measuring the thickness of the alloy layer. That involved knowing the density of that alloy, and, as he would be aware, the density of iron-zinc alloys presented a difficult problem, because they expanded tremendously when changing from one alloy to the other and porosity might develop. What value had he taken for the density? Elsewhere he had given figures which meant that the density had been calculated in proportion to the amount of iron and zinc in the alloy—the method of mixtures, as it was called in English—but it was impossible to do that if the alloy expanded tremendously when it was formed, so that it would be most interesting to know what figure had been used for the density of the various alloys.

Dr. Horstmann referred to troostite, which could be produced by direct quenching from the austenitic condition and also by tempering, by a reheating process. The first was in a strained condition and the second was not. To which type, therefore, was he referring?

Mr. K. J. Jameson (Thompson Bros. (Bilston) Ltd.), referring to the paper on galvanizing-pot construction, said that the welding of pots was not necessarily required to be of the same standard if the pot was to be used for coke firing. He had found that with coke-fired pots a two-year life was considered quite good, and the welding need not be of such a high standard as if the pot was to be installed in a controlled setting, where the life attained should be much higher. His company used different methods of construction when the pot was to be coke-fired. The welding was done in the normal fashion, but no particular control over the welding was enforced. He had found that in practice when pots failed it was always in the body material and not in the weld, so that it was considered that this type of construction was adequate. When the bath was to be in a controlled setting, on the other hand, different methods were employed; the plates were machined and the welds closely controlled and radiographed and stress-relieved before installation into the furnace setting. When customers asked for a bath they should give the bath manufacturer an idea of the type of setting which would be used. This would preclude the chance of a coke-fired-setting bath being installed in a controlled-bath-setting plant, resulting in earlier failure than would otherwise occur.

### Influence of Impurities

Mr. Chr. C. Lepage (S.A. Sambre-Escaut, Belgium) said that the impurities in the iron might modify its structure to a very great extent, and the difference in performance which resulted when the metal was galvanized might be far greater than those due to temperature. With low-carbon steel the structure would differ from that with high carbon steel. That might play a role in the later behaviour of galvanized wire after it had been drawn; there could be a difference of as much as 70 to 80 per cent. in the performance of such wire. Trouble might be caused if the impurites present favoured corrosion after the wire had been installed, particularly if recirculation heating was used. In addition to the content of the steel it was also necessary to pay attention to the way in which the steel had been treated, whether it had been rolled or drawn and whether the production processes used would have any effect on the later behaviour of the product after it had been galvanized.

Mr. W. L. Hall (General Galvanizers Ltd.) said that in the paper on galvanizing-pot construction a recommended composition for the material of the galvanizing bath was given. He thought that it would be fair to say that that was representative of the material being used for galvanizing baths in the United Kingdom today. In Mr. Gloor's paper, presented at the previous session, Fig. 3 showed that the galvanizing bath was made of Armco iron, and Mr. Hall believed that that was common practice in some Continental countries. He

would like Dr. Horstmann or some other delegate who used Armco iron for his galvanizing baths to say whether or not the additional expense and the difficulty of obtaining that material in large quantities were really justified from the point of view of good service life.

Dr. Hughes had referred to the fact that a high silicon content in the steel could to some extent be neutralized if the zinc used for galvanizing contained aluminium. It would be interesting to know whether anyone operating the Sendzimir process, with probably the highest aluminium content technically usable, had been able to take advantage of that fact to widen the composition specification for the material for the galvanizing bath, or whether they would still use a very low carbon, low silicon steel, or even Armco iron.

Mr. Hall wished to mention one practical point which emphasized the need for careful welding techniques, to which reference had already been made. He had recently put out of commission in his works a thermostatically controlled coal-fired bath, which had been one of the original British baths, if not the original, of that type of construction. It had had an operating life of about ten years, which was a remarkable comment on the efficiency of that type of bath heating from the point of view of bath life. The interesting point for the present discussion, however, was that that bath, when it eventually failed, failed in the weld; he would have been able work it for a considerable time longer if the weld had not been excessively alloyed. He did not know whether any difficulty had been experienced in the preparation of the weld or whether the el ctrode used had been of non-uniform quality and had left a rather higher silicon content in the root of the weld, but it had been a weld failure, even after ten years.

### Attack on Bath Margins

Dr. R. Haarmann (Sieg ner A.G., Geisweid, Germany), referring to attack on the margins of the bath, said that in Germany he thought that this was mainly due to the design of the bath. There might or might not be side reinforcement. Where there was considerable static pressure the difficulties which arose could be overcome by reinforcing the corners, and by not having a right-angled corner but bevelling it off. This would do away with attack on the corners of the bath and help to balance the pressure throughout the whole of the bath.

Mr. Ch. van Kempen (Johan Vis and Co. N.V., Amsterdam), adding to what Dr. Haarmann had said, said that he had had very good results up to now with three-plate construction of the pot by having the body of the pot pressed out of one piece of sheet with radiused corners of about 8 in. and then welded to it a top end with radiused corners. It would be interesting to know the views

*Mr. Ch. van Kempen raises a point in discussion.*

of the Technical Committee on that form of construction.

Mr. J. Slieker (Wilton-Fijenoord N.V., Schiedam, Holland), referring to the slide shown by Mr. Faulks of the failure of the bottom plating in a galvanizing pot, asked whether there was not a lead layer maintained in the bottom of the pot, and if not, why not? Would the authors give a general opinion on whether or not a lead layer should be maintained?

Mr. H. R. Breslau (Southern Galvanizing Co., Baltimore, U.S.A.) said that in the United States the general design of pot was very similar to that which Mr. van Kempen had just described, but the bottom plate was to the external dimensions of the pot and was welded on both the inner and outer sections of the walls and ends rather than conforming to the inside dimensions of the pot, as shown in Mr. Faulks' sketch. His company had had experience of nine pots designed in this manner and had never had a failure on the bottom of a pot.

Mr. A. F. T. Thomson (Smith and McLean Ltd.) asked whether Dr. Horstmann had investigated the use of aluminium fully killed steel for galvanizing baths, and if so whether he had found that a fully killed steel had better resistance to attack by zinc than a balanced steel.

Dr. D. Horstmann, replying to the discussion, said that so far as the pre-treatment of the steel was concerned, high-frequency furnaces were used and each pot processed weighed not more than 12 kg. Tests had been carried out for mechanical

strength and the results analyzed, and then the pots had been annealed or given further heat treatment to see whether there was any surface distortion. After annealing, further tests had been carried out over varying periods. With regard to the choice of steel, fairly clean material was used which contained in each case one element in different quantities in order to see the effect of the different impurities, whether one or several together. The zinc used was 99 per cent. pure, but of course, contained some impurities, because it was not possible to get an absolutely pure zinc, and therefore the impurities present were bound to have a certain influence. This was particularly noticeable if aluminium was present.

The surface behaviour was of great importance; he would say that the surface was even more important than the composition of the body of the steel, because when an object was immersed in the zinc bath it was the outside surface which came into contact with the zinc. It had been shown, in agreement with the findings of other engineers and metallurgists, that the zinc attack was particularly strong when carbon was present in lamellar form, but it was much less strong when the steel had a troostite structure. Further work was necessary in order to reach reliable conclusions on this, and before long it should be possible to obtain more information, which he would be very happy to communicate to fellow-members.

Mr. G. R. Faulks, in reply, said he had been very interested in the remarks of Mr. Hall about his coal-fired bath; a life of ten years had been obtained, and even then the weakness had been at the weld. That tended to confirm the opinion of the Sub-Committee. Mr. van Kempen referred to three-plate construction to reduce the welding to the minimum amount. The authors agreed with that, and Mr. Jenkins wished to say a word on the actual forming of the plate. Mr. Slieker asked about the lead layer. There was a 3-in. lead layer at the bottom of the pot. Mr. Breslau stated that in the United States the bottom plate was carried through to the outside dimension. That had been suggested to the authors, and they thought that it obviously needed further consideration. It had not been the general practice in the United Kingdom.

### Pot Construction and Plate Formation

Mr. W. A. Jenkins, who also replied, supported what Mr. Faulks had said on the question of pot construction and the forming of the plates. The Sub-Committee considered several ways of doing it, and the way mentioned by Mr. Breslau, of setting the sides of the pot on the bottom and welding both inside and out, had been part of their consideration. They also considered getting away from vertical corner welds by arranging for radiused corners and a centre weld in the sides or the ends, but Mr. van Kempen's suggestion, to have a radiused corner at the bottom and a centre weld along the length of the pot, they had not considered, and it was something to which thought should be given. With the increasing interest today in under-pot heating, he wondered whether it would mean exposing a weld there to conditions which might cause difficulty. On the general construction of the pot they had tried to cover as many practices in England as they could find and put forward what they felt should be a useful guide for those who were having new galvanizing baths made for their requirements.

Mr. J. N. Park (Thompson Bros. (Bilston) Ltd.) referred to what Mr. Hall had said about the galvanizing bath which lasted for ten years and failed at the weld and remarked that ten years was a long time, so that it would probably be very difficult to find out exactly what electrodes had been used on that weld; but weld design today was much more advanced than it had been ten years ago.

With regard to pot construction, he would like to assure the Technical Sub-Committee that it was possible to make galvanizing baths up to about 6 ft. in length from two plates, not three, with fully rounded corners and one vertical weld, and with the bottom plate welded in.

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## Session V

*Chairman:* M. VILLESUZANNE (Chairman, Association Technique de Galvanisation)

### "The Galvanizing of Triple-twist Netting"

By Chr. C. LEPAGE (S.A. Sambre-Escaut, Belgium)

THE triple-twist netting usually galvanized in Europe is made of wire twisted in alternate pairs to obtain a hexagonal mesh. The wire ranges from 14 to 23 B.W.G. and the mesh from 5/16 to 4 in. The zinc pick-up varies from 10 to 20 per cent., according to the type of netting.

Netting is always made of annealed wire, and the method of annealing is important as it governs the degreasing and pickling process that follows. Pot-annealed soap-drawn wire is apt to have areas coated with decomposed soap that is not removed by acids or alkalis. The trouble may be overcome by opening the pots before the wire cools. White annealed wire is clean, but tends to oxidize rapidly. Salt-bath annealing in a molten mixture of potassium chloride and sodium carbonate is best because of its speed and uniformity and the ease with which residues are washed off. After washing, the wire is pickled, washed and neutralized.

Some lubrication is necessary before weaving into netting, and if an oil is used it can generally be removed by adding a wetting agent to the pickle solution. Wire that has been salt-bath annealed can be lubricated by treatment with borax after pickling. The netting is subsequently washed in hot water which dissolves the borax and removes any oil derived from the loom. Further,

the netting is then hot when it enters the hydrochloric acid pickle, so that pickling is faster and more thorough. The pickling should preferably be done in acid consisting of two volumes of commercial hydrochloric acid mixed with one volume of water, *i.e.*, 200 to 225 gm. per l. HCl maintained at 20° to 25° C. A wetting agent is added, but no inhibitor, and the time of immersion is 10 to 15 min. The rolls are stored in still water while awaiting galvanizing.

In modern continuous operation the netting is next unrolled through a preflux consisting of zinc chloride solution at 10° Be and then passes through a dryer at a temperature between 180° and 250°, depending on the type of netting and the length of the dryer. Galvanizing is carried out at 440° to 455° C, and as the netting emerges it is wiped as clean as possible by passing through a bed of wood charcoal.

The speed at which the netting passes through the zinc bath must be kept the same for a particular type of netting, and other factors, such as the zinc temperature and the wiping conditions, must also be carefully controlled. A thermostat should be used to regulate the bath heating and the weight of zinc in the bath should be at least 1·8 times the weight of netting galvanized in 24 hours to ensure temperature stability. Whether the final wiping is done with wood charcoal or ash, the bed of material must be kept at a constant level and if ash is used it must be renewed from time to time.

Various kinds of machine are used to coil the galvanized netting. A double coiler has the advantage that stopping time can be practically eliminated: when one coil is complete, the netting is cut with flying shears and attached to the second coiler. Another system has a loop of netting between the zinc bath and the coiler, so that the galvanizing need not be interrupted at all while the coils are changed.

The zinc consumption depends very much on the size of mesh and gauge of wire, being greatest for fine meshes and thin wires. The following figures compare the efficiencies of a new plant and one that it replaced:

| *Some consumption figures* | *Former plant* | *New plant* |
|---|---|---|
| Production per hour | 200 kg. | 3 to 400 kg. |
| Zinc consumed per ton galvanized | 270 kg. | 170 kg. |
| Dross per ton galvanized | 28·2 kg. | 10 kg. |
| Oxides per ton galvanized | 70 kg. | 17 kg. |
| Hydrochloric acid per ton galvanized | 42 kg. | 20 kg. |
| Fuel per ton galvanized | 1,500,000 cal. | 620,000 cal. |

Mr. Chr. C. Lepage (S. A. Sambre-Escaut, Belgium), in presenting his paper, said that one of the new words which had come into current use was "productivity", which was of importance in any well-operated galvanizing organization. It was, he thought, closely linked to hourly output, and both terms meant more or less the same thing, because productivity referred to the production of the factory. Productivity was a measure of the efficiency of the galvanizing plant. It involved the ability to speed up or slow down various operations in the plant to meet the requirements of other operations. The speed of passing netting through the galvanizing bath, for instance, could not be looked at only from the point of view of how much material could be put through, but must be regarded from that of the operations as a whole, including the need for regular and even winding or coiling of the netting, which was highly desirable.

He hoped that the present processes of galvanizing would be improved, because there was still much to be done. That, indeed, was the object of the Conference.

### "The Galvanizing of Cast Iron"

By S. A. HISCOCK (B.N.F.M.R.A.)

When iron castings are galvanized for times which would produce a completely satisfactory coating on mild-steel articles, bare patches often remain. To obtain a complete coating immersion times of 15 to 20 minutes are sometimes used and as articles are often immersed in batches, some may be in the bath 30 minutes. Consequently the galvanizing of cast iron is often accompanied by the formation of much dross and heavy coatings.

A detailed study was therefore made of the problems involved in galvanizing castings and the effects of the type of iron and its composition and structure on dross formation and coating weights. Certain grey iron castings were very difficult to galvanize satisfactorily even after thorough pickling in hydrochloric acid, and examination of the areas showed that the difficulties were always associated with surface porosity in the casting which was probably caused by burnt-out sand before the casting was dipped. There was no indication that difficulties depended on the composition or structure of the irons within the range examined. Malleable cast irons appeared to present no difficulties. Satisfactory coatings were obtained on the difficult types of grey iron casting after shot-blasting.

The galvanizing characteristics of grey, white and malleable irons were studied to determine whether there were notable differences between them in respect of rate of dross formation and/or zinc pick-up. The amount of iron transferred to the galvanizing bath increased with immersion time and it was of the same order for high-silicon grey iron and for white iron as for mild steel; for malleable iron and low silicon grey iron larger amounts of iron were transferred to the bath. The amounts of iron transferred depended in some cases on whether the specimen had been prepared by pickling or by shot-blasting.

In general the zinc pick-up on the specimens also increased with immersion time, but with some materials, *e.g.*, low-silicon grey iron and mild steel, the effect was small, indicating that the alloy layers were less strongly adherent on these materials than on the others. The zinc pick up was least for the high-silicon grey iron—of the order of a half of that for mild steel—while the white iron and the malleable iron formed relatively thick coatings, with the low-silicon grey iron having an intermediate behaviour.

The composition and structure of grey irons were examined in more detail.

Only small differences were found with short immersion times in the amounts of dross formed and in the amounts of zinc picked up by the various materials. With longer immersion times the irons of relatively high silicon and phosphorus contents formed much less dross and thinner coatings than those of low silicon and low phosphorus content.

It is concluded that the practical difficulties in galvanizing cast iron arise from patches of sand on the surface of the casting, which are not removed by the cleaning processes normally used. Provided castings are thoroughly cleaned satisfactory coatings of about 2 oz. per sq. ft. per side may be obtained after 2 to 3 minutes' immersion at 450° C. If longer immersion times (15 minutes) are used in galvanizing grey iron castings, zinc consumption may be very high with irons in certain composition ranges. The lightest coatings and least dross formation are obtained with high silicon (3 to 4 per cent.) and high phosphorus (about 1 per cent.) contents. Similar reductions in zinc consumption may be made by shot-blasting and reducing immersion times, but the cost of shot-blasting must then be taken into account.

(In the absence of the author, Mr. S. A. Hiscock, his paper on "The Galvanizing of Cast Iron" was presented by Mr. E. C. Mantle (British Non-Ferrous Metals Research Association).)

## "The Galvanizing of Angle Sections"

By Dr.-Ing. J. FRIELI

THE investigations were intended to find out the optimum conditions for galvanizing angle irons. Two firms co-operated in the tests in which both new angles and those which had already been galvanized and stripped were used. The samples were pickled in hydrochloric and immersed in the galvanizing bath at a series of fixed temperatures from 420° to 470° C for immersion times varying from 1½ to 15 minutes. The coating weight was found by weighing before and after galvanizing, by chemical stripping and by an electromagnetic instrument. The ductility of the coatings was examined by bend tests. Coating weight and ductility tests were also carried out on sample rods cut from the galvanized angles.

The measurements of coating weight obtained by the three methods agreed well with each other. As expected, longer immersion and higher temperatures produced thicker coatings on the new samples which tended to pick up most zinc in the first two minutes and in the last six minutes of immersion. The coating weight on the used angles increased with longer immersion times, but not with rising temperature, the thickest coatings being obtained at 420° or 425° C.

The ductility fell as the coating weight increased, as would be expected. Some differences in ductility were found between the coatings on the old and new angles, differences which cannot be explained by the present series of tests.

A temperature of between 425° and 450° C and an immersion time of about six minutes were found to give the most satisfactory coatings.

(In the absence of the author, Dr.-Ing. J. Frieli, his paper on "The Galvanizing of Angle Sections" was presented by Mr. B. Brodbeck (Verzinkerei Pratteln, A.G., Ziestal, Switzerland).)

Mr. B. Brodbeck, in presenting Dr. Frieli's paper, said that the examination of 60 galvanized angle-irons which it described, represented a small effort to study the most suitable galvanizing conditions to ensure the optimum thickness, adhesion and ductility of the coating and to avoid any warping. Swiss customers were very particular in their demand for high-quality galvanizing. Among the important structural purposes for which galvanized angle sections were used in Switzerland were the structures for carrying the overhead wires of the electrified railways and the pylons used for the overhead line transmission of power. They had endeavoured to work with the railway and power authorities and to co-ordinate the trend of their research work accordingly.

Certain problems arose in connexion with the steel, because in Switzerland the steel was of very variable quality, the quality depending mainly on the pretreatment. Great care had therefore to be exercised in regard to bath temperature and immersion time. The results given in the paper led to the question of what ought to be done to achieve a really good coating in galvanizing angle irons and other articles. He did not believe that bath temperature and immersion time could be standardized; it was necessary to have regard to the type and shape of the objects to be galvanized, and in this field the exchange of experience was of particular importance.

## DISCUSSION

Mr. R. E. Copelin (Boulton and Paul Ltd.), referring to Mr. Lepage's paper, said he did not feel qualified to discuss the actual drawing or annealing of the wire, but he would like to ask the author to add some remarks on the particular things which should be done in the treating of the wire to avoid re-galvanizing. The author did not say how much re-galvanizing had to be done or what percentage it represented, but no doubt he did, like everyone else, have this trouble, and it would be interesting to know whether in his case it amounted to less or more than 2 per cent. It would also be of interest to have information on the correct method of making wire to avoid work hardening in the drawing process. In the heavier gauges it was sometimes found that, due to twisting in the loom and other strains, fracture occurred when tight-rolling netting for export, for example. It did not often happen, but it did occur.

### Use of Trichlorethylene for Degreasing

The author's reference to the use of trichlorethylene for degreasing was interesting. His company had a small plant installed for the purpose, but it was only rarely that it was used. It had been installed to deal with the fine mesh material if trouble occurred, but, as the author pointed out, it was costly to run, and the plant had not been used for some time. It was considered not to be a practical proposition on a large scale.

The use of soluble oil as a lubricant on the looms was also his company's practice. In Mr. Copelin's experience it was not just the oil on the wire or the

type of wire which caused trouble and led to the need for re-galvanizing. There were some wires which caused trouble due to the oil and which without the oil would be satisfactory, and at times the same oil would cause no trouble. He noticed that the strength of the acid used, as mentioned by the author, was the same as he used, but the strength of the flux was less. If he used the strength of flux mentioned in the paper he thought that there would be more trouble in re-galvanizing.

The section of the paper which appealed to him most, though unfortunately there was not time to discuss it properly, was that which dealt with the speed of passage of the netting through the galvanizing bath, and all the factors which influenced the coat. He would like to have specific instances of the effects of all those factors. He wondered whether the author could give some indication of the depth of wipe which he considered most suitable, and whether he would agree that the lower it was possible to go in temperature the better and more even and thinner the coat was.

In the consumption figures given at the end of the paper, the fuel per ton galvanized in the new plant was given as 620,000 cal. Presumably that meant kilocalories, 1 kcal. roughly equalling 4 B Th U. That figure seemed to be high from Mr. Copelin's experience. He had compared it with the figures given in Mr. Fagg's paper for gas-fired baths, which averaged about 1,750,000 B.Th.U. per ton of work. The figure in the present paper was nearly 2,500,000 B.Th.U. Mr. Copelin linked that up with the author's Fig. 3, which showed the drying of the netting before it passed into the zinc bath. That was a very interesting point. Mr. Copelin did not know of any other firm in Europe that dried the netting in a tunnel before it went into the bath, though he believed that drying was carried out in America. The heat from the drying would be carried into the bath, but he wondered whether that drying operation, coupled with the fact that the throughput was not as great as their own, accounted for the high figure of B.Th.U per ton of work. He had wondered originally whether to have a drying tunnel, but there was no space available and the extra cost was an important factor. He noted, however, that the author's figures for dross and ash formation were smaller than his own, while the deposit on the work was a little greater. By and large, however, the efficiencies seemed to be about the same as for his own works, so that he would be grateful if the author would help him to decide whether the drying tunnel was really worth while.

Mr. J. R. Rouff (Ets. Schmid, Paris), discussing the paper by Mr. Hiscock, said that in his company's factory they galvanized malleable cast iron with an immersion time of 40 sec. and obtained a very good coating. So far as sand in the castings was concerned, foundry workers could deal with this problem in making their own castings, but for job galvanizing it was another matter. Occasionally he had found that the foundry could not get the proper type of sand for the moulds in which the castings were poured, and then the surface was not as good as it should be.

### Surface Preparation of Castings

On the question of preparation, his company had always used shot-blasting followed by immersion in hydrochloric acid, but a short time ago the shot-blasting machine became due for replacement and it was decided to use the pickling system. The installation consisted of a bath containing the salts, with thermo-electric control and a fluxing bath, with running water. The castings were piled in baskets, which ensured good contact with the electrolyte and made them easy to handle. Care was taken to avoid blisters, which would, of course, impede proper contact between the salt solution and the metal surface. An electric current was passed through the bath. If the bath was negative there was reduction; if positive, there was oxidation. With blackheart castings or grey cast iron the reduction stage lasted, according to the composition of the castings, from 5 to 12 min., and the oxidation stage 15 min., with a fluxing time of 14 min. The parts on leaving the salt bath were passed through running water to wash off any remaining salts; any carry-over of the salt could be most harmful and spoil the surface of the part. The success of the pickling process depended on the part being completely degreased and not carrying over any salt; otherwise re-treatment would be necessary, which would considerably increase the production costs and probably spoil the galvanizing technique.

Some big containers in which the parts were left for a day or two were also available. Before going to the galvanizing bath they were pickled again in hydrochloric acid. If the cast-iron parts had been properly cleaned they would pick up a sufficient quantity of zinc in the bath. The size of the salt bath was important; if it was too small the results would not be satisfactory. The fluxing bath must be very large. It was convenient to be able to use the salt bath for oxidation or reduction at will; it was thus a dual-purpose bath. The dangers of using hydrochloric acid were avoided and the operations were very quiet compared with shot-blasting, so that he thought that this method was to be preferred.

Mr. H. R. Breslau (Southern Galvanizing Co., Baltimore, U.S.A.) said that Mr. Northcott had dealt in his paper with motion study, and Mr. Breslau wished to refer to this again, particularly in connexion with Dr. Frieli's paper. During the first world war the United States had produced

a great amount of bar steel. He included in that term angles and rounds, Z bars and T bars and a number of other sections. It was found that the use of hand methods gave an inordinately slow productive capacity, and the time taken was too great to get the type of production of which the kettles were capable. It was found that 60 to 70 per cent. of the time was being lost in walking back and forth and pulling out angles. The materials had not been available at that time to mechanize, but as soon as they became available a magnetic roll set-up was developed which could pull the angles as fast as 300 20-ft. bars per hour, which in some cases gave a production of up to 10,000 lb. per hour.

The great problem in North America was the high cost of labour and materials, and it became most important for them to lower their labour cost per unit. Generally speaking, if the galvanizing cost exceeded half the basic steel price plus freight plus fabrication, galvanizing would be forgotten in favour of the use of such materials as aluminium. The relative prices of aluminium and steel in American were about three to one, the same as the weight ratio, so that every day they came into closer competition with aluminium fabrication.

### Automatic Handling Equipment

It was incumbent on them, therefore, to develop automatic or semi-automatic method of handling articles. It had the further advantage of providing a uniform time within the kettle which could be readily controlled, depending on the thickness of the angle. The thinner angles, of course, required less time in the kettle, and the whole operation could be speeded up to take care of that situation. Articles up to ¼ in. thick were in the kettle under the new method for less than 1½ min. This method, therefore, not only increased the productivity rate but gave the advantage of a constant immersion time, which, as the paper indicated, was very important. It also lessened the time. The method, therefore, had proved very satisfactory in giving a uniform product, one which did not vary too much from bar to bar, and an acceptable product so far as ductility was concerned, and a high-quality product which would meet the higher standards of the A.S.T.M. It was probable, however, that more could be done in the mechanization of bar galvanizing, as the paper suggested, and he would be interested in any further developments which might be brought to light in the United Kingdom or on the continent of Europe.

Mr. J. F. H. van Eijnsbergen (Dutch Galvanizing Institute, The Hague) congratulated his Swiss friends on the excellent paper which Dr. Frieli had written, which might serve as a basis for further experiments along the same lines, to enable galvanizers to meet the exaggerated demands of customers regarding the thickness of the coating to be applied, either according to specifications or in accordance with special orders. He would hesitate, he said, to place the paper in the hands of customers, having regard to the variations in thickness shown in Table I when galvanizing angle irons at 450° C.

There were three questions which he wished to ask. First, what was the author's definition of the bending coefficient? When bending steel covered with a coating of zinc, it was desirable to specify whether the outside of the steel surface or the outside of the zinc surface was taken in calculating the bending coefficient. Second, he took it that the samples had been pickled in hydrochloric acid of about 12 per cent. That was not stated in the paper. Third, had any experience been obtained of the relative brittleness and changes in ductility when galvanizing Siemens steel and steel of other types? Any comments which could be made on the influence of the percentage of nitrogen and phosphorus would be of interest in that connexion.

Mr. R. E. Nutt (Court Works Ltd.) expressed disappointment that Mr. Hiscock was not present, as he would have liked to join issue strongly with him. The paper, he said, was an endeavour to help galvanizers to galvanize a product which was full of surface defects, blowholes and burnt-on sand, and anyone who attempted to reach a solution of the problem of galvanizing that type of material was doing a disservice not only to galvanizing, but to the foundry industry. He would state definitely that there was no need to have long immersion times; cast iron could be satisfactorily galvanized in two to three minutes, and his company did it daily.

The problem, however, started in the foundry. Attention must be paid to the sand and a check made on the green strength, moisture and permeability, and it was his company's practice to do this at least every 15 minutes. Attention must also be paid to the running system, to ensure that the casting had a very good skin and was in the condition that a casting must be in for galvanizing. Why the galvanizer should be asked to finish a bad product he did not know. As a member of the Technical Committee of the Joint Iron Council, he would like the Zinc Development Association to take the matter up. Much of the bad work turned out by galvanizers was due to the fact that they had no opportunity to do a good job.

Fig. 5 in the paper seemed to be contradictory. It had been said that high silicon meant a thinner coating, yet in Stage 2 of Fig. 5 it was stated that there was zinc penetration along the graphite flakes. With high silicon there were more graphite flakes. It had been his experience over thirty years that the more graphite there was the heavier the coating, which was just the opposite of what was stated in the paper.

Mr. W. R. Thompson (Painter Brothers Ltd.) said that in presenting Dr. Frieli's paper Mr. Brodbeck had referred to the fact that in Switzerland it was necessary to galvanize varying qualities of steel, mild steel and high tensile steel. Most of the work which the speaker's firm galvanized was mild steel, but in recent years it had been found necessary to galvanize an increasing quantity of high-tensile steel. Could Mr. Brodbeck confirm the opinion that the coating on a high-tensile steel was thicker, given similar conditions of galvanizing, than that on a mild steel bar?

### Corrosion Resistance of Galvanized Wire

Mr. K. H. Hartung (Union Sils van de Loo and Co., Frondenberg, Germany) said the subject of galvanizing wire coils led him to put a question which might be regarded as on the fringe of the subject, but which was nevertheless of interest. Was it possible to increase the corrosion resistance of galvanized wire? In the German industry a distinction was drawn between hot dipping and what was called galvanizing, because by "galvanizing" was meant electroplating in an electrolytic bath. The zinc was deposited by the electrolytic process in a cold bath, but the hot dipping process was also used, in a hot bath, where the part was immersed and a layer of zinc adhered to the surface of the article. If the article was immersed for 10 seconds in a chromate bath a very thin film of chromate was deposited which had a very satisfactory corrosion resistance effect which raised the ordinary galvanizing efficiency by about 5 per cent. His company were able to turn out a special type of steel cable by the so-called passivation method which had excellent corrosion resistance, an attempt was being made to investigate this new type of galvanizing in the German Institute. It might also have the effect of increasing the brilliancy of the galvanizing. This might be found to be a very suitable process for the electrolytic type of galvanizing.

Mr. H. H. Ellison (Aberdare Electric Co. Ltd., Dublin), referring to Mr. Lepage's paper, said that his company were running a wire-netting plant and had had some experience of the problems involved. They would very much like to install a furnace for drying the wire netting before it passed into the zinc kettle, but this involved another process and another input of heat, and it added to the cost. The difficulty had been overcome by dosing the pre-flux tank with sodium alkyl sulphate, which was an excellent wetting agent which so reduced the surface tension of the flux solution that most of it came away from the roll of netting as it was lifted out of the flux, and it was dry in a matter of seconds, and certainly before it reached the zinc kettle.

They had also been anxious to improve the appearance of the wire netting and get a better lustre, from the point of view of customer psychology, and to reduce the amount of zinc carried out. Experiments with aluminizing the bath were carried out, but the ordinary methods did not prove successful. It was then found that it was possible to achieve the objective by introducing at about 1 ft. per hour 3-inch aluminium rod on each side of the roll as it was passing in. This had been adopted as a regular procedure, and a very high lustre was obtained while greatly reducing the zinc loss.

His company had found that it paid to use as low a temperature as possible in the zinc kettle; it normally ran at 440° C. His company were fortunate in having an excellent electrically heated zinc kettle and could maintain a constant temperature of $440 \pm 3°$ C at all times.

Mr. Chr. C. Lepage, replying to the discussion, said that Mr. Copelin had asked what was the rate of re-galvanizing. This was a difficult question to answer. If black annealed wire was used for galvanizing, 5 to 8 per cent. of the material had to be re-processed, because the processes of fabrication, etc., gave rise to a varied performance. With a better type of wire as little as 2 per cent. of the material had to be re-processed. Using soap-drawn wire, there was no re-processing at all.

Mr. E. C. Mantle, replying to the discussion on Mr. Hiscock's paper, said that Mr. Rouff had raised the question of the immersion time used in Mr. Hiscock's work. The time of two or three minutes had been chosen quite arbitrarily, as something within the bounds of practicability, and it was agreed that it would be possible to get satisfactory coatings on clean castings with very much shorter times of immersion. Mr. Mantle was very interested in Mr. Rouff's new method of preparing malleable iron castings for galvanizing. He was not sure whether it was an aqueous pickling solution or a fused salt bath*. Perhaps Mr. Rouff would say whether his treatment would really deal with sand inclusions or whether it only removed surface oxidation. It seemed to Mr. Mantle that the plant was suitable only for specialized galvanizing dealing solely with iron castings, and might not be of great interest to the general galvanizer.

He did not see what was the point of disagreement of Mr. Nutt with the paper. Mr. Hiscock was only trying to show that the difficulties with which the galvanizer had to contend were of the ironfounder's making. Unfortunately, the general jobbing galvanizer did not seem to have very much influence on the ironfounder and had to accept and treat the castings which the ironfounder produced for him. Unfortunately also, the British Non-Ferrous

* *A description of this process appears on page 258 of this issue.*

Metals Research Association had no influence on the ironfounding industry either; if it had been a question of non-ferrous castings they might have been able to do something about it.

The crack along the graphite flakes which Mr. Hiscock suggested would cause the large amount of dross formation would probably be noticeable only with long times of dipping, and with very clean castings and short galvanizing times the difficulty might not be encountered. It seemed to Mr. Mantle, however, to be a reasonable explanation of why large amounts of dross were formed, and in Fig. 27 of the paper there was some metallographic evidence that zinc penetration occurred along the graphite flakes, isolating the little crystals of iron, which then floated away into the bath, forming dross. The reproduction of the photomicrograph in question was not very clear, but it was quite clear in the original.

### Quality of Material to be Galvanized

Mr. B. Brodbeck, replying to the discussion on Dr. Frieli's paper, said that some questions had been put concerning the quality of the material to be galvanized. The material which his company had galvanized was war material, and still was. In 1943 they had been unable to import foreign material. He was afraid, therefore, that he was not in a position to give any precise information about the chemical analysis of the material used. In carrying out the galvanizing tests the author had concentrated attention on galvanizing as such. The author also stated that "At the time of these investigations no material of uniform chemical composition and properties was available" and so "to draw generally valid conclusions from the present results" was impossible. "The results may not, therefore", the author said, "in themselves serve as a basis on which to draw up quality specifications in respect of hot galvanized structural steel, but they may serve merely as a guide". Mr. Brodbeck, while therefore unable to reply to the questions on this point, promised to get in touch with Dr. Frieli and ascertain from him the exact composition of the material used in the experiments.

The pickling process was carried out in hydrochloric acid solution of 21 per cent. strength. For the most part they had used malleable homogeneous cast iron. He was afraid that he had not understood the question about the bend test coefficient, but he would deal with it in writing.

Mr. J. R. Rouff, commenting on Mr. Mantle's suggestion that the process he had described was of interest only for specialized cast iron galvanizers, said hat in ofar as his firm were general galvanizers they did not use it.

## Session VI

*Chairman:* Mr. V. J. E. DERRIDER (Travail Mechanique de la Tôle)

### "New Markets for Galvanizing"

By R. L. STUBBS (Zinc Development Association)

TWO years ago, at the Oxford Conference, an exploratory meeting was held to discuss the advantages which the galvanizing industry in Europe would derive from setting up a European Committee for the exchange of technical information and for co-operation in work to improve galvanizing technique and to develop new markets. The representatives of the various national Associations held other meetings in Paris and Brussels and in Germany at which they drew up a general plan for a European organisation which they thought would be helpful for the whole industry.

Some countries have national Associations which embrace all sections of the galvanizing industry—sheet and strip galvanizing, wire galvanizing and tube galvanizing as well as general galvanizing—and their idea was that a European federation should be set up which would embrace all sections of the industry. That, of course, is a very ambitious idea, and we have not so far been able to achieve it; but we have been able to bring one section of the industry in Europe into a European Association which is known as the European General Galvanizers' Association. I have been asked to say a few words about the activities of this new Association and to present my paper on new markets for galvanizing in a way which may stimulate a discussion on the activities of this new Association, and to show also how the Association can serve the industry in future and help it to develop new markets for galvanizing.

Since our last Conference, in 1954, Europe has enjoyed a period of steady and vigorous industrial expansion. Both in 1954 and in 1955 the galvanizing industry broke all previous records, and all countries have shared in this growth. Until 1953 industrial expansion was largely dominated by reconstruction and post-war needs, but in the last three years the expansion which has taken place has been based on rising standards of living and the demands of an increasing population; in other words, it is due to normal peace-time economic forces. The greater capital expenditure now being made by Governments and industry alike is a feature of the expanding European economy which should provide galvanizers with their biggest market and their best possible new markets in the future.

The recent progress is encouraging, and there is no reason why it should not continue. European industrial production has increased by about 19 per cent. since 1953. During the same period the amount of zinc used for galvanizing in Europe has risen from 320,000 tons in 1953 to 400,000 tons in 1955, an increase of 25 per cent. General galvanizing accounted for a large part of this expansion. In the same period the total European consumption of zinc rose from 724,000 tons to 925,000 tons, or by roughly 28 per cent. It expanded more rapidly than the production of galvanizing, but all the same galvanizing has been rising very steadily. If it is possible to continue to find important uses for galvanizing linked with capital expenditure, there is every reason to believe that this high rate of expansion can continue.

From the discussions which we have had at our Conference there have been many healthy signs that the industry is amongst those which are spending capital on new plant and equipment. It must continue to modernise itself if it is going to compete with other methods of corrosion prevention. The survey of European practice has shown that modern methods of bath heating are now more widely adopted, and we have heard of the universal interest in this subject. However, although a great deal more information has been distributed throughout Europe in recent years on the techniques of galvanizing, the survey shows that in practice there is still plenty of scope for the wider application of this knowledge. One of the objects of the new European Association is to help to increase the rate of technical progress in the industry.

It is, however, in the differences between the performance of plants that the surveys which have been made have been most interesting, since they show that some plants have a much better record of productivity than others. The steps which the British industry is taking to increase its efficiency and output have been described, and we shall certainly tell the European Association of our experiences in work study, in plant layout and in materials handling.

Our new Association can help to stimulate our interest in productivity and so help us all to cut costs. Once again this Conference has provided a forum for discussions on research work, and our new Association can play a valuable role in co-ordinating the work which is now being done in different countries and so ensure that the results are known to the European industry as a whole. The reports which we have considered cover only two phases of the research in galvanizing. Other work includes research on the corrosion resistance of galvanized coatings, the role of lead in hot-dip galvanizing, and the cause of failures of zinc and other modern coatings by some modern detergents. Research work is also being undertaken on coloured chemical finishes which will improve both the appearance of the galvanized surface and also its life. Important, too, is the work on welding galvanized material, which should, if successful, provide the industry with many new outlets.

Further, an important change has been taking place in galvanizing research programmes. Previously, most of the research on galvanizing has been concerned with improving the galvanizing process, but now much greater attention is being given to ways of increasing the applications of galvanizing. The work on the development of attractive colour finishes, on the welding of galvanized material, and on the development of paints for application to galvanized surfaces without pretreatment, should all help to expand the market for galvanized products.

All these subjects have been considered by our new General Galvanizers' Association, and will no doubt continue to occupy its attention for a long time. So far, however, the new Association has not drawn up a programme for developing new markets; and in order that the members of the Committee of the Association may hear the views of the industry as a whole on where our best hopes lie in the future, the paper will be followed by slides of modern applications of galvanizing in England and in some Continental countries, and perhaps experts from those countries can give information on the reasons which led to the adoption of galvanizing for the particular purpose illustrated. I hope that this will assist in drawing up a plan for increasing British markets.

Goods wagons are being galvanized in England for British Railways. The British galvanizing industry felt that there was a possibility of showing the railways that the galvanized goods wagon would be easier to maintain and would last longer than the usual painted wagons. Twelve of the wagons have been galvanized and are now in use in England. They are not to be inspected until they have been in use for three years, and so we know nothing of the results of this work yet.

## DISCUSSION

Mr. D. N. Fagg (Zinc Development Association) amplifying Mr. Stubbs' remarks, said the important point was that the conventional goods wagon, which was not galvanized but only painted, had a very short life, and it seemed that this would be a very useful potential application for galvanizing not only by virtue of the good resistance to corrosion of galvanized steel, but also because of its good resistance to wear. These wagons suffered quite heavily from abrasion under normal conditions, and in this type of application the galvanized coatings would do a useful double job.

The end section of a wagon of the conventional type would normally be painted. That was an important point, because it was an unwieldly structure for galvanizing, and if galvanizing came to be universally accepted for this application it would be readily possible to redesign the structure to make it easier to galvanize. The whole truck consisted of two end sections with a shorter centre-piece made up of the two doors.

Mr. Stubbs said he did not know whether there had been any experience in other countries of the galvanizing of goods wagons, but they would be very interested to hear of any progress which had been made in that direction on the Continent.

He was showing an illustration of a boom being lifted into position in an electrification scheme which was being carried out by British Railways. It was part of the structure carrying the overhead contact wires. Another illustration showed a section of the railways in Switzerland, and it would be of interest if Mr. Gloor or Mr. Brodbeck would say something about the use of galvanizing by the Swiss F d deral Railways. So far as Mr. Stubbs knew, they had been galvanizing the structures carrying the overhead wires for many years now, and it would be interesting to hear something of the economics beh nd this and to know something of the views of the Swiss railway authorities on galvanizing.

Mr. R. Gloor (A. G. Kummler and Matter, Aarau, Switzerland) said that he wa in a position to provide long-term data. The Swiss Federal Railways very rarely used painted material for rolling stock or structures, for self-evident reasons. Galvanizing would withstand the weather for many years. In the case of some galvanized structures built 30 years ago, inspection had proved undeniably

that they would withstand exposure to the weather for a further 30 years. It was possible to look forward, therefore, to a very great expansion in the use of hot-dip galvanizing for structural parts. The Swiss Federal Railways decided many years ago that all material used for electric traction should be galvanized, both static structures and wagons. A recent trend had been to introduce galvanizing also for a number of component parts in bridge construction. In future years it was expected that hot-dip galvanizing would be used for treating all the parts purchased by the Federal Railways. After galvanized material had been in use for a few years it became evident that galvanized parts would have an extremely long life when properly galvanized and that galvanizing offered several advantages over other types of protection, so that the decision was made to adopt it almost wholesale.

For uses where finish was important, galvanized articles could be painted to produce most attractive results for display purposes in stations and so on, where appearance counted for a great deal. People in the industry should be told what the European General Galvanizers' Association was doing and the contacts which had been made. Their members should join with them in the work of research and development and remember that satisfactory results depended on co-operation amongst galvanizers. In that way they would undoubtedly find new outlets, if they acted as members of one big family, exchanging facts and knowledge.

### Use of Galvanizing by the Netherlands Railways

Mr. J. F. H. van Eijnsbergen (Dutch Zinc Institute) said that the Netherlands Railways were very galvanizing-minded. They had started about 20 years ago on the electrification of the whole railway system, a very dense system, and they had a great deal of experience of galvanizing. They prescribed 600 gm. per sq. m., which meant 2 oz. per sq. ft., and the life of the pylons and booms and other parts of the catenary had been very good for many years. The cover-plates for the switch-wires were also galvanized, which gave very good protection.

At the present time the Netherlands Railways were coming to the end of their electrification programme, in which diesel-electric traction played a part, and were facing the reconditioning of old booms which had been standing for from 10 to 17 years. Generally speaking, there were two systems in use, the first being the repainting of the galvanized booms, masts and so on with iron oxide paint, which gave an extra protection. The Netherlands Railways laboratories were very satisfied with the hot-dip galvanized coating, because it served as a 100 per cent. sound basis for painting and costly and time-consuming cleaning methods were not necessary. There was no time for such methods on the railway system, which was occupied day and night. There were only 24 steam locomotives left, and it was hoped soon to reduce the number to 10, so that there was not much time available for repairs.

Tests had recently been made with zinc-dust paints, which had been described to the Conference on the first day. The experience with those paints had been very satisfactory, especially as not much cleaning was required, and even if there were a few local spots of rust special cleaning methods were not necessary. The Netherlands Railways, in their efforts to get the best corrosion protection, had chosen hot-dip galvanizing, and there was no doubt that this process would continue to be used.

Mr. Stubbs then showed an illustration of structural steelwork at one of the National Coal Board mines in England which had been galvanized. Another illustration showed galvanized pit tubs in Holland. Since he understood that the galvanizing of pit tubs had been carried further in Holland than in other countries, it would be interesting to hear Mr. van Kempen on the subject.

Mr. Ch. van Kempen (Johan Vis and Co. N.V., Amsterdam) said that the galvanizing of pit tubs in Holland began in 1935. In the early days only about 20 per cent. of the tubs were galvanized, for use in mines where there was danger of severe attack by acids and so on. During the war it had been impossible to galvanize the pit tubs, but it had been found that the galvanized tubs stood up much better to wear and tear than the painted ones, and that ability to withstand a bad environment was less important than the advantage of reduced maintenance costs. By 1950 about 90 per cent. of the pit tubs had been galvanized, and so far as he knew there were now no more painted tubs in use in Holland. About three years ago some comparative tests had been made of pit tubs painted with a very cheap bituminous paint, others with zinc sprayed on and others galvanized. By keeping the price very low for galvanizing, which was possible when dealing with large quantities, galvanizing had won the battle of the comparative coatings.

### Galvanizing of Railway Structures in Germany

A German Delegate said that in Germany the galvanizing of overhead railway structures for the contact wires of electrified lines had been shown to be successful, and efforts were being made to persuade the railway authorities to adopt galvanizing, but it had been difficult to do so. Pit tubs in Germany were galvanized, and comparisons had shown that hot-dip galvanizing offered serious advantages over other types of protective coating.

The surface was more corrosion- and weather-resistant, and that was particularly important for the inner surfaces, which came in contact with the coal or other minerals, and which had shown themselves when galvanized to be far more resistant than other types of protection. In German mines the trend was to adopt a very hard and rather thick galvanized coating.

Mr. STUBBS then illustrated a galvanized steel structure for a school. In England, he said, the use of prefabricated structures, particularly for school buildings, had increased in recent years. A simple structure of the type shown would be clad with a facing material on the outside and with wall panels on the inside. Some of these structures were being galvanized, but not all. This might prove a very good application of galvanizing. He understood that Mr. Fagg had some information about the use of galvanizing in this field.

Mr. FAGG said that there were two big advantages in using galvanizing for this purpose. One was that these structures were often left lying about on the site for a long time before being finally used, and galvanizing ensured that they remained in fairly good condition. The other was that normally in designing these structures a fairly large allowance had to be made on the section thickness to cater for corrosion, and when the steelwork was galvanized that corrosion allowance could be reduced very substantially, so that the amount of steel involved in a given structure was much less. He believed that there was also a third factor, a psychological one, that the workmen usually preferred working with this type of material, because it was so much cleaner. That could be an important point.

### Galvanizing of Steel Windows

Mr. STUBBS added that in England most of the steel windows were galvanized, and, since they formed part of buildings, the Conference might like to hear from Mr. Wilson the reasons for the adoption of galvanizing by the steel window industry in England.

Mr. E. M. WILSON said that before 1935 there had been little attempt to rustproof steel windows in the United Kingdom. By that time, following the considerable increase in building in the 1920's, the difficulty of keeping the steel windows in good condition had become apparent, and local authorities reached the stage of feeling that the maintenance problem with steel windows was such as in some instances to preclude their use. The more progressive ste l-window manufacturers, therefore, realized that something must be done and took steps to have a standard specification drawn up for rust-proofing by various processes. When that was introduced, it was not long before galvanizing showed that it was much more satisfactory than any of the other rust-proofing processes in the specification. Today, therefore, at least 90 per cent. of the steel windows made in Britain were hot-dip galvanized.

In addition to the use of galvanizing for windows, it had been found that other internal fittings in buildings would be far better galvanized than treated by other means, particularly in multi-storey buildings where maintenance was very expensive. Another development was for the sheet metal sills often used on large buildings, often made of 15- or 18-gauge mild steel, to be galvanized, so that today a very large proportion of the steelwork used in the building ind stry was galvanized.

Mr. STUBBS then showed the galvanized flooring in a power station, and then, turning to another type of use, illustrated a television tower under construction in London which was completely galvanized, and asked Mr. Thompson to say a few words about the use of galvanizing for these towers and for other construction work of that nature.

Mr. A. H. THOMPSON (General Galvanizers Ltd.) observed that it would be obvious that structures of this kind would require a great deal of maintenance if they were to be painted, so that it was for the benefit of the customer to galvanize them. The B.B.C. always specified that their television masts and wireless towers should be galvanized, and the Independent Television Authority were doing the same. An interesting feature of the tower illustrated was that the main legs were formed from four $7 \times 7 \times \frac{7}{8}$ in. high-tensile angles bolted together, and the customer specified that the mating surfaces of those angles should be coated, after galvanizing, with calcium-plumbate paint, to which reference had been made in an earlier paper.

Mr. STUBBS's next illustration was of a lamp-post, of a type familiar on the Continent as well as in the United Kingdom, and this was followed by some galvanized deck fittings on a ship. He had always felt, he said, that this was one of the most important uses for galvanizing, and he invited Mr. Stewart to give his views on how this market might be expanded and whether there was any trend towards the greater use of galvanizing by shipbuilders.

Mr. R. STEWART (Smith and McLean Ltd.) said that the shipbuilding industry had been well informed for very many years about hot-dip galvanizing, and at the present time the problem was to get the industry back to it, because, for example, aluminium fittings were being used for the deck, and copper and plastic piping. Zinc-rich and other paints had been used to a large extent.

Mr. STUBBS invited Mr. Busch-Jensen to give his views on the trends in Denmark, particularly in the shipbuilding industry.

(*Continued on page* 256)

# THE EUROPEAN GENERAL GALVANIZERS' ASSOCIATION

## A Statement on its Origins, Activities and Aims

THE European General Galvanizers' Association, of which Dr. H. Bablik is the first president, met for the first time last November in Amsterdam. It seeks to promote technical co-operation in the general galvanizing industry in Europe and to find new markets and applications for the process. Membership includes national galvanizing associations from Belgium, Denmark, France, Germany, Italy, the Netherlands, Scandinavia, Switzerland and Britain. The Zinc Development Association, which has always fostered both international and national co-operation in the zinc-using industries, is acting as the first secretary to the new association, which the Hot Dip Galvanizers' Association, affiliated to the Z.D.A., has helped to set up.

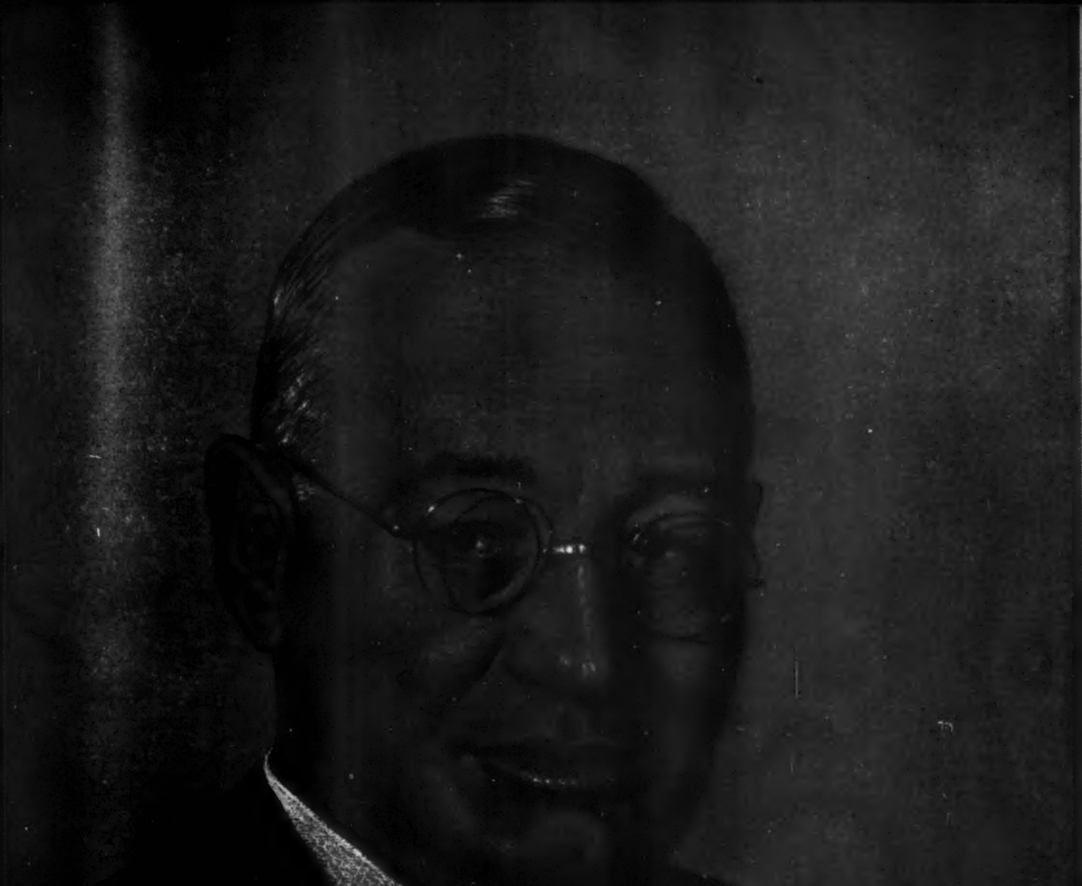
In 1949 the Z.D.A. played an active part in encouraging British galvanizers to establish the H.D.G.A. which now includes nearly all the firms in the British galvanizing industry. At that time galvanizers were convinced that a combined effort would improve the progress and efficiency of their industry and the Association's work over the last seven years has proved the practical advantages of co-operative research and discussions. The first galvanizing association to be set up in Europe after the war, the H.D.G.A. now has 85 members in Britain and 28 Commonwealth members and the support of many European firms who subscribe as foreign corresponding members to keep in touch with research and progress in Britain. Its Technical Committee, composed of experienced galvanizers, encourages research and has instigated much fundamental work on galvanizing, quite apart from advising the industry's customers who can freely submit their galvanizing problems. Today the British galvanizing industry, largely as a result of the Association's work, is undoubtedly one of the most advanced technically in the world.

To help improve and maintain the industry's efficiency, a productivity service has recently been organized with the aid of M.S.A. counterpart funds and the Association's industrial engineering staff have visited works in Britain, making detailed recommendations, many of which have already been put into practice. The Association has thus taken the initiative in an industry which consists mainly of small firms, sometimes unable to afford their own industrial engineering section and the productivity service provides them with the opportunity of consulting experienced advisers and of obtaining technical help with their own particular problems.

Co-operation became international at the first conference on hot-dip galvanizing, held in Copenhagen in 1950 and attended by some 90 delegates from all over Europe. This international meeting and the example of the H.D.G.A.'s work encouraged many European countries to set up similar national galvanizing associations. Further international conferences have been held at Dusseldorf (1952), Oxford (1954) and Milan (1956) and the next will take place in Brussels during the International Fair year (1958). Apart from the technical papers and discussion, the conferences, held every two years, afford delegates the opportunity to visit foreign galvanizing works and to examine different techniques and equipment.

At the Oxford conference several delegates suggested the establishment of a permanent European organization which could meet at frequent intervals to exchange technical information. A proposal for a federation of European galvanizers was discussed at a series of exploratory meetings and as a result the European General Galvanizers' Association was formed. An extensive programme of work has already been drawn up and it includes the preparation of European standards for galvanizing and investigation and research into several common problems. Regular collection of statistics which will show the industry's progress and help galvanizers find and develop new markets has already been arranged through the Association's secretary, the Z.D.A.

Under its distinguished first president the European association can look forward to many years of increasing service to the galvanizing industry and—no less important—to its customers.



**HEINZ BABLIK**

*Professor Dr.-Ing. (Vienna)*

*President of the European General Galvanizers' Association.*

*Personality Spot*

## HEINZ BABLIK

*Professor Dr.-Ing.(Vienna)*

HEINZ BABLIK, Prof. Dr.-Ing.(Vienna), first President of the European General Galvanizers' Association, was born in Vienna in 1900. After graduating at the technical University of Vienna in 1923, he gained the degree of Dr. techn. with a thesis on "The Gain in Weight in Galvanizing". In 1932 he was appointed a lecturer at the University in the field of metal corrosion and protection, being created Professor in 1941. Since leaving the University Dr. Bablik has administered the works founded by his grandfather, which has become the largest hot-dip galvanizing installation in Austria.

His interest in hot-dip galvanizing from his early studies has led Dr. Bablik into a close study of all aspects of the subject on which he has been a prolific writer. His book on the subject, for long a standard work, has appeared in three English, three German and one French edition, and further German and English editions are in preparation.

Widely known as a consultant on the galvanizing process, Dr. Bablik was recently elected the first President of the European General Galvanizers' Association—a body which was formed last year largely on the initiative of the Zinc Development Association, and which aims to promote the technical development of hot-dip galvanizing throughout Europe.

# OVERSEAS REVIEW

## A Quarterly Survey of some of the Features in Finishing Literature from Abroad

by SCRUTATOR

### Aluminium

As predicted, aluminium continues to find increasing uses in American automobiles. A special Alcoa survey report shows that whereas the average 1955 passenger car contained 29·6 lb. of aluminium and its alloys, this-year's models contain 35·2 lb. This means that some 246 million lb. will be used of which approximately 50 per cent. will go into automatic transmissions, 30 per cent. into engines and about 7 per cent. into exterior car trim. This last figure corresponds to nearly 17½ million lb. of aluminium, which represents a very large surface area—the greater proportion of which was probably previously electroplated.

On a more specific application, an interesting account has recently been published of a completely automatic installation for the aluminizing of valve faces at the Pontiac Motor Division of General Motors. The valves are first heated to 450° F, the "faces" aluminium sprayed, and the valves then reheated to about 1,450° F to diffuse the aluminium into the metal surface. All finishing operations including grinding the valve stem and lapping the seating surfaces are performed prior to aluminizing. It is stated that in addition to improving the oxidation resistance of the valve steels, the alloy layer materially reduces the amount of deposits that adhere to the valve-seat faces during engine operation. In cars subjected to accelerated performance tests, no aluminized valves failed in cars operated for more than 50,000 miles whereas failures in uncoated valves began at about 25,000 miles.

### Titanium

A serious disadvantage of titanium and its alloys is that they show a marked tendency to gall and seize when in moving contact with themselves or other metals. Recent work at the Battelle Memorial Institute for the Chief of Ordnance which was sponsored by Waterton Arsenal has indicated that surface conversion coatings provide a very promising method of overcoming or reducing this. Although anodizing for 20 minutes in 5 per cent. caustic soda at 205° F and 50 amp. per sq. ft. gave good results in galling tests using a molybdenum-disulphide grease as lubricant and also showed promise for assisting wire-drawing, the simple value and it is estimated that such treated titanium chemical immersion treatments are almost certainly of more general interest. The operating conditions and composition of three baths are given which are based on potassium-fluoride/hydrofluoric-acid mixtures with either trisodium phosphate or sodium borate as the other constituent. Depending upon which solution is employed, the treatment time may be 1 to 20 minutes and the operating temperature 80° F to 185° F. Analyses of coatings produced from the high-temperature (185° F—10 minutes) trisodium phosphate variation showed rather unexpectedly that they contained 39 per cent. F, 25 per cent. K, 17 per cent. Ti and only 3 per cent. $PO_4$. In plug-drawing tests (using a suitable lubricant) a maximum reduction of 65 per cent. was obtained, laboratory wire-drawing trials looked promising and good results were obtained in reciprocating wear high-speed wear tests. Again, rather surprisingly it was found that this increased wear resistance was produced by the formation of a layer of titanium dioxide adjacent to the metal. Further investigation showed that the oxidation rate of titanium is significantly increased by these immersion conversion coatings, although the temperatures at which the increased oxidation rate and improved wear occur are below those affecting the structural characteristics of the metal.

Another method which is claimed to overcome these galling and seizing characteristics is the electrodeposition of a special hard, ductile chromium plate (0·002 to 0·030 in.) which can be deposited directly on to titanium and aluminium. No details of the process have been released other than that the procedure for titanium comprises (*a*) surface cleaning; (*b*) surface activation (Baylig process); (*c*) chromium plating. Some 150 titanium-alloy pistons chromium plated in this manner have been used in "an experimental weapon".

In addition to these metal-finishing treatments for titanium and its alloys, the metal itself is being used in the United States for anodizing racks. At Douglas Aircraft Co., specially treated titanium contact points are reducing costs and improving the operating efficiency of chromic acid anodizing by limiting the peak current density to 2 amps. per sq. ft. Repeated use of the racks does not lower this

(*Continued on page* 256)

# GOLD FINISH FOR ALUMINIUM

A NEW and, it is claimed, revolutionary method of producing non-fading gold-coloured aluminium in a variety of shades and tones has been developed by the Kaiser Aluminium and Chemical Corporation of California.

The colour is, to quote the company's words, "built in" to the metal itself, and is brought out by anodizing under readily controlled conditions without the use of dyes or other colouring materials. It may be varied from pale straw to deeper gold and gold-bronze tones, and the finish may be either bright or satin.

Because of the permanence of its colour, the new Kaiser gold aluminium is especially suited for a wide range of exterior architectural applications, cars, furniture and home appliances.

The gold aluminium has been produced experimentally at the corporation's Trentwood, Washington, rolling mill, and will soon be commercially available in sheet form.

In the first stage of production, certain readily alloyed constituents are added to molten aluminium. The colour of the resulting alloy is that of normal aluminium and remains so until it is anodized.

The new alloy will be supplied for most applications in sheet form as an integrated cladding on standard aluminium alloy sheet.

Different shades are produced by altering the anodizing conditions, and various surface finishes may be given the metal before anodizing to provide degrees of brightness or surface effect.

The gold aluminium has been subjected to an ultra-violet exposure test simulating seven years of exposure to the sun under the worst ultra-violet conditions known to exist in the United States. The colour change was found to be imperceptible to the eye. The material is therefore substantially more sunfast than the best known colour anodic coatings which have been used for outdoor aluminium applications.

As with existing anodic finishes, the new gold finish provides additional protection against corrosion and resistance to wear. In addition, it withstands high temperatures without loss of colour.

**Overseas Review**

(*Continued from page* 255)

points save 1·5 kW per sq. ft. in each anodizing cycle. (The treatment consists of cleaning in hot 50 per cent. (v/v) nitric acid, rinsing and drying, followed by heating to 1,300° F for 1 hour.)

**Proprietary Processes**

It is not the usual policy of this quarterly summary to focus attention on proprietary processes, but two recent American articles justify some reference to the processes concerned. The first announces the successful operation of the Ransburg No. 2 Process for the application of vitreous enamel to washer and dryer parts at Appliance Park, General Electric's giant appliance plant in Louisville, Kentucky. After less than a year in production, almost a million sq. ft. of cover coat are produced each month. Advantages reported are: a reduction in the weight of applied enamel to 23 gm. per sq. ft.; improved coating thickness uniformity and consequent good appearance and chip resistance; negligible equipment maintenance; and a wide range of production rates—up to 20 ft. per min. if parts do not exceed 30 in. in height.

The second concerns a new series of chromate solutions in the Iridite range for treating copper. The Iridite 7 process enables copper and most of its alloys to be chemically polished to mirror brightness, the resultant surface resists tarnishing, and chromium can be directly plated on to the brightened surface without intermediate nickel plating. Metal is removed at a rate of 0·0002 to 0·0003 in. per minute at 80° to 120° F.

**Galvanizing Conference**

(*Continued from page* 251)

Mr. H. BUSCH-JENSEN (J. Chr. Jensens Galvaniserings Etabl., Copenhagen) did not think it could be said that there was any special development taking place in the use of galvanizing for ships' fittings in Denmark, except that it increased with the increase in shipbuilding, and in Denmark more ships were being built and the yards were being enlarged. Danish shipbuilders were fully aware of the merits of hot dip galvanizing; they were not abandoning it, but were making great use of it.

Mr. STUBBS said that the Land Rover car, which was made in England and which he illustrated, was interesting because it contained many parts which had been galvanized. The bumper, the grille and many of the fittings round the windscreen were galvanized. It was felt that this was a field which could be exploited; there should be great opportunities for galvanizing in agriculture. This was an example of a motor-car manufacturer producing an all-purpose car for use under all kinds of conditions in the country and protecting it against rusting by galvanizing. The makers of agricultural equipment should follow this trend.

Unfortunately there was no time to discuss these uses of galvanizing, though there had been some very interesting information on the practice of some railways, and about the galvanizing of pit tubs in Holland and Germany, with some suggestions for the use of galvanizing in building. It should be of interest if the Association would prepare reports on what was being done in these different fields for circulation to all the members.

# FINISHING NEWS REVIEW

## THE ERFTWERK PROCESS

### First U.K. Licensee

IT has been announced by The London Aluminium Co. Ltd., Westwood Road, Witton, Birmingham 6, that they have been appointed the first licensed operators in this country for the Erftwerk process of chemically brightening aluminium. Considerable interest is currently being shown in this process, some technical aspects of which were discussed recently at the annual conference of the Institute of Metal Finishing. Aluminium brightened by the process has been finding increasing application on the Continent in applications which have hitherto been the traditional preserves of nickel/chromium plate.

In the operation of the Erftwerk process components are immersed in a solution which consists in the main of ammonium bifluoride and nitric acid. The rate of attack on the metal is very high and brightening is achieved within 20 to 30 seconds. Unlike other processes, careful prepolishing is not essential, and besides saving labour costs on this, the process is valuable in dealing with components which are difficult or impossible to polish.

After brightening, components are given a special anodizing treatment, at high voltage and low temperature in a sulphuric-acid electrolyte and the anodic film is then sealed in boiling water. If desired this film can be given any colour required, by immersion in a dye vat, prior to sealing. The hard transparent oxide film which has been formed gives protection against attack from industrial and marine atmospheres.

Only super-purity base material will give an anodic film of sufficient depth to ensure durability, which yet remains transparent. With lower grades of aluminium, the impurities will blur this film, thus impairing brilliancy.

A three-year trial period in replacing chrome-plated steel, brass or zinc by super-purity aluminium in automobile trim has led the German car industry to use this material on an ever increasing scale. In this period virtually no claims for replacement of super-purity parts were made, and manufacturers have expressed complete satisfaction with the working characteristics of the material. Firms using material treated in the way described include Volkswagen, Mercedes-Benz, Porche, Borgardwerke and Lemmerzwerke.

The development of this process will provide an attractive, durable and economical product which should have a great appeal for a wide range of industrial and domestic products.

## New Metal-finishing Courses at Borough Polytechnic

A SANDWICH course in applied chemistry and chemical technology which includes metal finishing as a subject and also paints and allied technologies will begin at the Borough Polytechnic, London, S.E.1, on September 20. This is the first course of its kind to be organized in the United Kingdom. It will be of four years duration, with an optional fifth year for students who wish to complete Grad. R.I.C.

All students will follow certain general courses, but will be able to choose one group of optional subjects which, in addition to metal finishing or paints and allied technologies, can be oils, waxes and detergents, or plastics and high polymer technology.

The standard of entry for this course will be either:

G.C.E. (Advanced Level) in chemistry and physics with some ordinary subjects; O.N.C. in chemistry with additional subjects; or College entrance examination.

There is provision for an additional preliminary year for students who do not fulfil these entry requirements. Alternate periods of six months in the Polytechnic and in industry are the basis of the sandwich course.

The Polytechnic authorities are already in touch with some firms who wish to second employees as "works based" students to the course. Firms who have no suitable employees available at the present time are invited to discuss the possibility of the recruitment of "College based" students as trainees.

## Institute of Vitreous Enamellers

### Change of Chairman

On his taking up an appointment in Southern Rhodesia, Mr. H. Laithwaite, managing director of Metal Porcelains Ltd., has resigned from the office of chairman of the Institute of Vitreous Enamellers to which he was elected at the beginning of the year. At a recent meeting of the Council of the Institute Mr. W. Thomas was unanimously elected to the Chair as successor to Mr. Laithwaite.

## ZINC CONTROLS CORROSION

A NEW 16 mm. sound and colour film entitled "Zinc Controls Corrosion" has been produced by the American Zinc Institute Inc. and was shown to a small gathering recently at the offices of the Zinc Development Association.

Through the very effective use of animated diagrams and colour photography the film, which has a running time of approximately 35 minutes, demonstrates the general electrochemical mechanism of corrosion and of the protection afforded by zinc.

After showing in its opening sequences how important sound corrosion prevention methods are, the film goes on to explain in easily understandable terms how zinc controls corrosion, not only by forming a protective coating, but also by affording galvanic protection. The film then reviews the methods for coating steel with zinc and surveys the various applications of zinc coated parts.

It includes descriptions of some new continuous galvanizing lines, the hot-dip galvanizing of large structural parts, and other effective means of using zinc for corrosion prevention as cathodic protection, metal spraying, sherardizing, and metallic zinc pigmented paints.

Copies of the film for showing to agricultural, industrial, technical and educational groups can be booked without charge from the Zinc Development Association, 34 Berkeley Square, W.1.

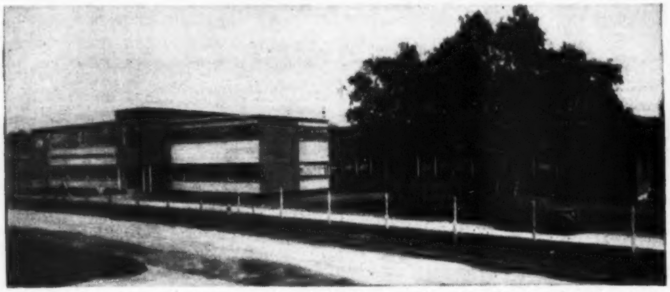
FINISHING NEWS REVIEW

# PLATING SUPPLY FIR

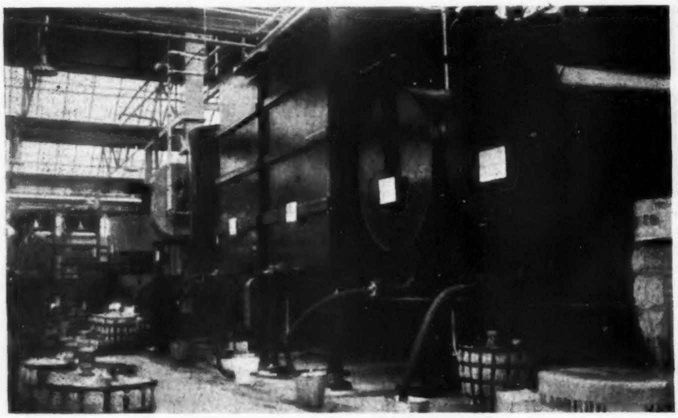
## New Premises at Woking for Electr

THE increasing activities of the Electro-Chemical Engineering Co. Ltd. and the expansion of the company's business during the last few years have now made it essential that all activities should be operated from one factory. Previously, complete manufacture had been carried out at the EFCO works at Burton-on-Trent and by various sub-contractors, but the new factory at Sheerwater, Surrey, which was opened recently makes provision for the carrying out under one roof of engineering work, chemical mixing and packaging, and the laboratory analysis of process solutions. The engineering activities of the company comprise the assembly and mechanical testing of Efco-Udylite automatic machines; it is also planned to manufacture other products at present being sub-contracted. The chemical products which are mixed and packaged at the new factory, comprise the range of chemicals used in the various Efco-Udylite processes, while the routine analysis of customers' solutions can be carried out at regular intervals as part of the free service given. In the development laboratory and demonstration plating shop new processes can be tried out and demonstrated.

The Electro-Chemical Engineering Co. Ltd. was formed in 1939 as a wholly owned subsidiary of Electric Furnace Co. Ltd., now EFCO Ltd., and has previously been situated at Weybridge, Surrey. During the war its activities were concerned with the

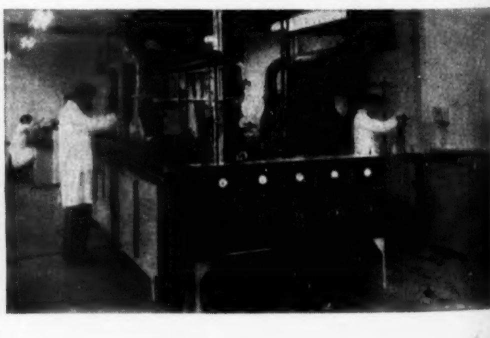


*General view* (above) *of new works of the Electro-Chemical Engineering Co. Ltd., with office block in left foreground.*



(Above): *Mixing equipment for chemicals.*

(Below left): *Efco-Udylite automatic plating machines under construction.* (Right): *Demonstration plating shop.*



# OVES TO LARGER SITE
## emical Engineering Co. Ltd.

design and manufacture of automatic pickling machines for ordnance work, and after the war these activities were extended into the production of general contінous pickling and electroplating plant. One such installation for Maclean and Co. (Metal Windows) Ltd. at Hamilton, Lanarkshire, is still one of the largest electroplating installations in Europe.

In 1947 a long term agreement was made with the Udylite Corporation of Detroit which put Electro-Chemical Engineering Co. Ltd. in the position, not only of being able to build automatic machines of the "return type" to Udylite designs, but to build fully immersed electroplating barrels and other equipment and to supply Udylite bright plating processes comprising bright nickel, bright zinc and bright cadmium.

In 1954 an agreement was made with Solventol Chemical Products Inc., Detroit, under which the company was licensed to manufacture Di-Phase cleaning equipment and cleaning processes. A Metal Cleaning Division was accordingly formed to handle Di-Phase equipment, automatic trichlorethylene degreasers and ultrasonic cleaning equipment for which the company has a selling arrangement with a Swiss firm. It has been evident that there is a large demand for modern cleaning installations for a variety of metal components and precision parts.

The rapid development of the company's business during the last ten years has resulted in a ten-fold increase of sales turnover. The greater awareness of the importance of finish and a shortage of suitable labour has encouraged many firms to mechanize their electroplating and to adopt processes which reduce or eliminate hand polishing. The continuing research and development activities of the Udylite Corporation has also resulted in a flow of new products and processes becoming available through the Electro-Chemical Engineering Co. for the European and Commonwealth markets.

One example of a notable installation was the provision of two electro-galvanizing lines for zinc plating steel sheets for John Summers and Co. Ltd. A third line has recently been completed. These machines are over 200 ft. long and include cleaning, plating and phosphating cells through which steel sheets are continuously passed.

The site on which the new factory has been built has an area of three acres, the initial development being over a frontage of two-thirds of the site. It consists of six bays each 35 ft. in width, five of these having a length of 66 ft. and a height to the underside of truss of 16 ft. The sixth has a length of 88 ft. and a height to the underside of truss of 23 ft., this bay having a 3-ton overhead crane. Three bays are in use for chemical products and three for engineering. A building 20 ft. in width is connected to the main factory and runs the full width of the six bays (210 ft.); this contains the demonstration plating shop, analytical and development laboratories and offices for chemists. To the north is a separate office block with two floors which is connected to the works by a covered way and provides accommodation for engineers, draughtsmen, purchasing and sales departments and administrative personnel. The floor area of the factory is 21,000 sq. ft. and that of the office block 7,000 sq. ft. It is planned to lay out the area adjacent to the office block as a garden and to retain as many existing trees as possible.

FINISHING NEWS REVIEW

### Chemical Mixing

The chemical mixing platform has been designed so that raw materials are brought to it by fork-lift trucks and are added to the various mixing tanks after measuring. Raw materials are stored on pallets in the works and a store for finished products and space for export packing has been provided. After stirring, solutions are filtered and pumped to storage tanks and filled into carboys. A fume extraction system has been incorporated. Special corrosion-resistant materials have been used in view of the chemicals being handled. Many of the tanks and much of the pipework are rubber-lined, others are in stainless steel with ducting made of plastic material.

### Demonstration Plating Shop

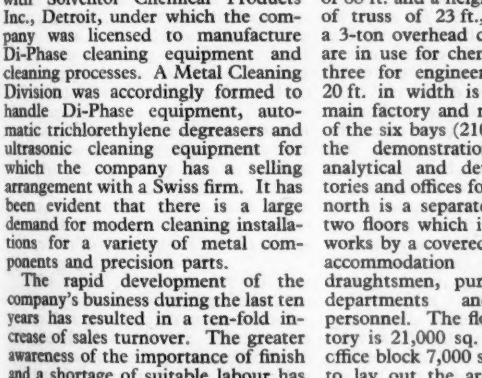
The demonstration plating shop equipment has been specially designed to enable a wide variety of electroplating processes to be used. There are eight separate services, namely, a.c. and d.c. electrics, hot and cold water, steam, gas and low and medium pressure compressed air. Exhaust ducting is of rigid P.V.C. construction. The false ceiling is formed of Asbestolux slabs and vapour proofed fluorescent lighting has been provided. An effluent disposal plant is included to purify wastes from the chemical mixing plant and the demonstration plating shop.

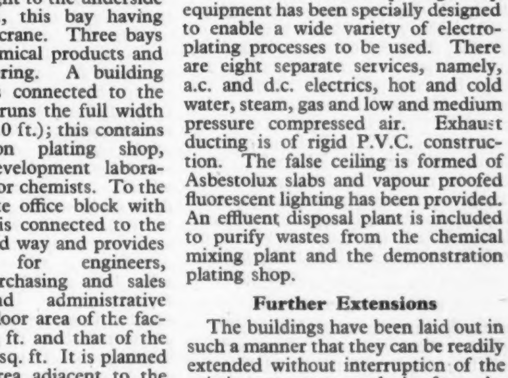
### Further Extensions

The buildings have been laid out in such a manner that they can be readily extended without interruption of the existing processes and, in fact, the

(*Continued in page* 260)

(Left): *Drawing office and* (right) *part of analytical laboratory.*





FINISHING NEWS REVIEW

## SHOTBLASTING SERVICE

A NEW shotblasting service has been set up by R. J. Richardson and Sons Ltd., which is trading under the name of Shotblasting (Midlands) Ltd., Forge Lane, Cradley Heath, Staffs.

There is a large shotblast room to deal with iron and steel castings up to 1 ton in weight and 12 ft. long, in addition to shotblast chambers for smaller work and a Tilghman rotary blast-barrel wheelabrator to deal with small castings and forgings in bulk.

The new works are in the charge of Mr. J. H. Wood, who has experience in both the shotblast and peening processes.

It is claimed that work delivered will be received, processed and ready for collection in 24 hours.

### Plating Supply Firm Moves

(*Continued from page* 259)

present layout has been made in accordance with the ultimate requirements, when the factory will have been extended by at least 100 per cent. Provision has also been made for the extension of the office block by 70 per cent. Service roads have been laid out with the future extensions in view and provide access to hard standings where drums and containers are stored externally. Separate access is provided to the office block and chemical and engineering blocks.

The chairman of the company since its inception has been Mr. D. F. Campbell, who is also chairman of EFCO Ltd., Davy and United Engineering Co. Ltd., Metallurgical Equipment Export Co. Ltd., and Campbell, Gifford and Morton Ltd., who were consulting engineers for the whole of the new factory. The manager of the company is Mr. Alan Smart, B.Sc.; he is assisted by Mr. J. H. Gifford who has been especially concerned with the planning and erection of the new works.

Mr. H. J. Bache, A.R.I.C., is chief chemist, and the board of the company has recently been joined by Mr. H. Silman, B.Sc., F.R.I.C., F.I.M., M.I.Chem.E., who is a past-president of the Institute of Metal Finishing.

# CLEANING OF IRON CASTINGS

## *Demonstration of Electrolytic Process*

A process for the cleaning of iron castings which has achieved a measure of success in the U.S.A. is now being operated under licence in the U.K. by Castingite Ltd., Stone Yard, Deritend, Birmingham 21. Known as the Kolene process and developed by the Kolene Corporation, Detroit, U.S.A., this cleaning process lends itself particularly to the removal of core sand, foundry scale, rust, silica, and carbon inclusions from inaccessible parts of ferrous castings.

Castingite Ltd., which is a subsidiary company of the Birfield Organization, has been formed comparatively recently and not only operates the process on a jobbing basis, but also furnishes and maintains the process and the necessary equipment to large scale users.

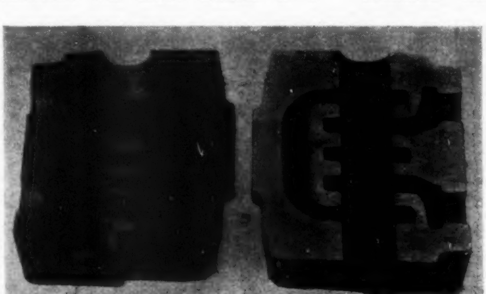
Few technical details concerning the exact nature of the process have so far been released, but the efficiency with which it performs its stated functions was made evident at a recent demonstration. The process consists essentially of a bath of molten salts, principally caustic soda, into which the components are immersed. The work is connected to a six or eight volt D.C. source of suitable amperage for the area of surface to be treated. For most cleaning purposes the work is made cathodic, the anode being the walls of the tank.

With the workpiece negative reducing conditions prevail at the surface of the work resulting in the removal of sand, scale, rust or other oxides. For certain specialized applications the work can be made anodic, giving rise to oxydising conditions at the surface which serve to remove oil or grease, or other organic contaminants, including graphite. Under these conditions the process serves as an effective preparation of a cast iron surface for subsequent hot tinning.

The equipment required for the operation of the process is quite straightforward, consisting of the Kolene tank, which may be heated by any available means, followed by a cold water rinse and a hot water rinse; an adequate ventilation hood is also necessary. The D.C. requirements can be met by the use of suitable rectifiers.

Apart from the cleaning of ferrous castings, the process as described also lends itself to the preparation of bearing backs for subsequent white metalling, and of castings or forgings prior to brazing or silver soldering.

Different formulations of the Kolene process are also available for paint stripping and for descaling of stainless steel strip.



*Iron castings containing intricate cored holes sectioned before and after treatment by the Kolene process.*

The Kolene process can be adapted to most production operations, either as a separate unit or incorporated into an automatic line. In some of the installations operating in the U.S.A., incorporating specially designed conveyors, six tons of castings are handled per hour completely automatically, and even with units of the small batch type it is possible to process up to 500 lb. of castings per hour.

### SCHOLARSHIPS IN METAL FINISHING

#### *Developments at Nottingham University*

A scholarship for research in the field of metal finishing to the value of £600 per annum has been established by W. Canning and Co. Ltd., Birmingham, in the Department of Metallurgy of Nottingham University.

The Electro-Chemical Engineering Co. Ltd., of Woking, Surrey, have also offered £300 a year for three years to the Department towards the cost of a scholarship for research in metal finishing.

# TESTING COLOUR-MATCHING APTITUDE

A METHOD of measuring aptitude for colour matching has been introduced by the Inter-Society Colour Council of America and two sets of the equipment developed by this body are now available in this country. One has been installed by the Printing, Packaging and Allied Trades Research Association in their laboratories at Leatherhead, and the other has been presented to the Birmingham College of Arts and Crafts by Boxfoldia Ltd., carton manufacturers, of Birmingham.

The number of colours that can be distinguished by a normal human eye runs into many thousands although there is a considerable difference between people in their ability to distinguish colours. A few people have colour deficient vision, usually showing itself as an inability to separate reds from greens with certainty; there are many tests by which this condition can be diagnosed, the best known being the Ishihara test.

However, even people with vision that is physiologically normal differ in their ability to separate colours that are very close to one another and to make accurate colour matches. Reliable tests to measure this ability are difficult to devise.

The I.S.C.C. test is designed to test this ability to make accurate colour matches. It is not intended to be used for detecting colour deficient vision, although a person with colour deficient vision will not often do well at the test.

The test consists of a board about 18 x 14 in. with four rows each containing 12 coloured plastic chips, size 1 x 1¼ in. Those in the top row are blue; the second, red; the third, green; and the fourth, yellow. All the chips in any one row differ slightly from one another. The subject is given, one at a time and in random order, 48 similar plastic chips, each of which matches one of the chips on the board. He holds his loose chip against each chip on the board in turn and marks the square on the board that he thinks is the closest match.

The scores given for each match made are graded according to the closeness of the match. For instance, an exact match may score three, but there may be two other chips on the board that would give a score of two if matched with the same loose chip. The scores have been assessed from a statistical analysis of the matches made by 200 subjects before the test was put on the market.

The maximum possible score is 109, but the results are usually given as gradings, as differences of less than five between scores are not considered significant. The gradings are excellent, good, fair and poor.

The rating gained by a subject will give some idea of how suited he is for tasks involving close colour matching, although for some jobs, such as the formulation of inks or dyes, other skills—the ability to predict the result of adding a given dye to a mixture—may be more important.


## FLAME CLEANING OF GRICULTURAL EQUIPMENT

ONE OF the important problems facing the agricultural industry is the maintenance of farming tools and machinery. Equipment which is subject to all weather conditions easily becomes corroded, and the wide use of chemicals in manures and fertilizers can have an adverse effect on farming implements.

Corrosive deposits can be chipped away by hand or with a wire brush, but this method is a lengthy one and does not ensure that the surface is absolutely clean and free from moisture, an important factor if paint is to be applied.

Flame-cleaning can be used on all types of farming equipment ranging from manure-coated shovels, forks and wheelbarrows to ploughs and tractors. It can also be used satisfactorily on farm outbuildings and general field structures, such as steel fencing, and drinking and feeding troughs.

Flame-cleaning equipment manufactured by British Oxygen Co. Ltd. is now being used on more than twenty Scottish farms.

## INSTITUTE OF VITREOUS ENAMELLERS

### *Midland Section Programme*

The Midland Section of the Institute of Vitreous Enamellers has announced its programme for the forthcoming session as follows:

*November* 29, 1956
"The Care and Maintenance of Vitreous Enamel Plant" by J. H. Mayall.

*January* 31, 1957
A paper on Sheet Iron Enamelling by G. A. Greenwell.

*February* 28, 1957
"Some Aspects of Cast Iron Enamelling and Its Future in the Cooker Industry" by J. Bernstein.

*March* 28, 1957
Section Annual General Meeting followed by "The Serviceman's Aspect on Vitreous Enamelling" by D. Mill.

*May* 2, 1957
"Development of Enamels" by W. A. Ball.

The Section Dinner will be held at the Station Hotel, Dudley, on January 11, 1957.

**The original building in which Metals and Methods made their first heat in October, 1948, has for some years been inadequate to meet the increased demands for their production of high quality nickel alloys and plating anodes.**

**They have recently moved to a new works designed and built solely for melting and finishing their specialized products, which are used by non-ferrous founders, nickel silver makers, manufacturers of nickel copper alloys, wire, strip, sheet, tubes, electro-platers, etc.**

**These new works, which are sited between the railway and the canal at Langley, Buckinghamshire, have greatly improved facilities for storage, handling and close technical control of their products, which will enabled them to give better service in the future.**


## TECHNICAL AND INDUSTRIAL APPOINTMENTS

The appointment of Miss Dorothy Pile as technical information officer to the **British Jewellers Association** has been announced. Miss Pile will be in charge of the recently formed technical department.

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With effect from July 4, Mr. N. C. Pearson has been appointed assistant managing director of **Borax Consolidated Ltd.** Mr. C. M. Houlton becomes general sales manager with Mr. A. G. H. Bell as assistant sales manager.

The managing director, Mr. F. A. Lesser, will continue to devote his attention to finance, accounts, and questions of policy, while Mr. Pearson assumes responsibility for the day-to-day management of the company.

**Mr. R. T. F. McManus**

A well-known personality in the plating industry, Mr. R. T. F. McManus, has been appointed technical service manager of **Silvercrown Ltd.,** 178-180 Goswell Road, London, E.C.1. Previously at the Tin Research Institute and Ascot Gas Water Heaters Ltd., Mr. McManus has for the past eight years been in charge of the plating section of the laboratory of the Pyrene Co. Ltd.

# TRADE and TECHNICAL PUBLICATIONS

**Barrel Finishing:** We welcome a newcomer to the number of domestic publications in the field of metal finishing under the title of "Roto-Finish Roundabout" produced by Roto-Finish Ltd., Hemel Hempstead, Herts. The first issue describes the company's processes of precision deburring and polishing and includes a contribution from the technical director of the American company which originated the process.

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**Pre-Treatment:** The fourth issue of "Pretreatment News" issued by Imperial Chemical Industries Ltd., features the use of the company's Granodine phosphate coating process as a preliminary to painting of Nash-Kelvinator refrigerators. The process is carried out in an eight-page pre-treatment spray tunnel.

The issue also includes detailed drawings of a design for a gas-heated Granodine tank prepared by the Paint Division of the Company in consultation with the Gas Industry.

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**Enamel in Architecture:** The current issue of the International Enamelist, a quarterly journal published for private distribution by The Ferro Corporation, Cleveland, Ohio, U.S.A., contains a description of a twelve-storey building erected in Salt Lake City, which has been clad externally in enamelled steel curtain walling. The enamelled panels to a total of 75,000 sq. ft. were provided by Seaporcel Metals Inc., New York, and consist of shaped vertical ribbing with a textured ceramic surface. The panels, each 4 x 4 ft., were assembled in threes to a steel grid to form a 4 x 12 ft. unit which was then fastened to the main steel structure by angle clips.

The building is framed in rust-coloured vitreous enamel panels with portions of the facade in off-white and grey.

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**Degreasing Fluid:** A leaflet from Bartoline (Hull) Ltd., Myton Place, Hull, describes the use of "Barol" degreasing fluid, a specially formulated solution of water soluble solvents for the rapid removal of oil and grease from machinery, metal components, floors and walls, etc. In use the parts to be cleaned are brushed, sprayed or dipped with the fluid as supplied, brushing or soaking being continued until the oil and grease is dissolved. The parts are then washed or hosed down with clean cold water leaving a grease-free surface for which rust resistant properties are claimed. The fluid is non-caustic, non-fuming and non-injurious to the skin, and is not subject to evaporation. Further information and samples of the fluid are available from the makers.

**The Cellon Bulletin:** There are several interesting articles dealing with various aspects of paint application and utilization in the July issue of this broadsheet produced by Cellon Ltd., Kingston-on-Thames, Surrey.

One article is concerned with a weldable primer which has been developed to overcome the difficulty widely experienced in the engineering industry. This primer, Cerrarc, permits the striking of an arc on steel without the prior removal of the paint. It offers no significant obstruction to the manipulation of the arc during welding, either in the up or down position and has no adverse effects on the strength of the weld.

Another article deals with printed circuits in the manufacture of wireless sets. A special copper-clad laminate is used as the base panel and a print of the circuit or wiring diagram is applied by the silk-screen process. When dry the panel is immersed in an etching bath and the unprinted areas of copper are etched away to the insulated base. The Cerric ink, which possesses special acid-resisting properties, remains as printed with the copper beneath it unaffected. The ink can then be easily removed and the panel is ready for further assembly and if necessary dip soldering.

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**Stoving Enamels:** Technical pamphlet No. 52, produced by Wm. Harland and Son Ltd., Merton, London, S.W.19, describes the use of epoxide resins in surface coatings and the part that they play in the production of stoving enamels.

Stoving enamels based on epoxide resins have exceptional properties of adhesion to all metal surfaces including polished aluminium; flexibility; hardness and chemical resistance.

The pamphlet then describes the two types of enamel that the company have evolved that cover most normal industrial requirements. The first of these is Harpoxide (general purpose) stoving enamel, which is intended for use where a top grade stoving finish would normally be specified. It is suitable for all types of equipment and domestic appliances where resistance to abrasions, knocks, splashing with fats and detergent solutions is likely to be required and is available in black, white and in the company's normal range of shades.

The other type is Harpoxide (high duty) stoving enamel, which is intended for use in cases where the main object is to produce a finish with the highest possible chemical resistance.

The pamphlet finally describes the method of application and the stoving schedule for each of the enamels.

# Latest Developments in PLANT, PROCESSES and EQUIPMENT

## Paint Spraying Equipment

THREE new additions to their range of paint spraying equipment have recently been introduced by Atlas Copco (Great Britain) Ltd., Beresford Avenue, Wembley, and are described here.

*307 Spray Gun*

This gun has been designed to give the same rate of production and degree of atomization with a cup gun as is obtained on the production line with a pressure feed set-up.

It is fitted with the same air cap as the Ecco 30 spray gun for pressure-line feed and has fifteen air holes as opposed to the usual four on the standard suction-cup cap at present employed in the industry.

A special reducing valve built into the spray gun, automatically taps off pressure on to the paint in the cup itself, which is forced up to the fluid nozzle enabling the supply of air to be fully employed on atomization. As a result, a much greater volume of air is passed through the gun as the extra paint is being passed to it from the pressure-feed cup.

A finer degree of atomization is obtained and it can use materials of a higher viscosity than is possible with a suction-feed gun.

The cup is fastened to the gun by a simple triple-bayonet clip ensuring even pressure on the cup when it is pulled up on to the air-sealing washer. Because of the very fine bore of the fluid nozzle, it is necessary to have a special needle. Otherwise this equipment is similar to other guns in the Atlas range in that the trigger, air valve, spring controls, back head and glands are universal.

This gun can also be employed with the Atlas KV 3 cup heater for garage work.

*H3C Two-gun Hot-Spray Unit*

This new unit (Fig. 1) is half the size and weight of the earlier Atlas hot-spray unit and is 23 in. in height. It can be used to operate two separate colours or materials at the same time through two spray guns.

It has been designed to overcome the problem of wear normally associated with the use of pigmented materials in hot-spray equipment, incorporating gear pumps in the fluid circuit. There is no circulation of the lacquer, but the material is kept hot between unit and guns by a constant flow of hot water through a water jacket encasing the paint hoses. The new design replaces the gear-type paint pump which was liable to wear caused by heavily pigmented fillers and enamels, and will spray these materials with no maintenance other than an occasional oiling. The paint is delivered to the gun at the rate of 15 gal. per hour with only 1° F loss between unit and guns on a length of hose up to 30 ft.

Weighing only 70 lb. it can be employed as a portable unit, and is fitted with a 2.7 kw. heater and the temperature of the paint is controlled by a thermostat set between 30° C and 95° C.

In use the unit is attached to a pressure container, spray guns and an air transformer. If it is to be used with cellulose materials, an automatic pressure switch is incorporated which passes current only when positive pressure exists in the connexion chamber.

In operation, paint from the pressure container passes through the paint coil immersed in the water container. The water is heated by the element and the paint is raised to the correct temperature which is maintained between unit and guns, by means of a triple hose through which hot water is circulated. This comprises an outer water hose, an inner water hose and a paint hose, the water hoses providing a water jacket for the paint.

*Catalyst Spraying Equipment*

At present most organic finishes dry by evaporation of solvents and the subsequent curing of the film by oxidation, in the case of air-drying materials, or polymerization in the case of stoving materials. During the last few years certain finishes incorporating resins of the urea-formaldehyde, polyester and epoxide group have been formulated which, in conjunction with a catalyst, produce a final film which has far tougher and greater wearing qualities than any other material produced in the organic field of finishes.

As it is necessary to add the catalyst only immediately before use, there has been a need for equipment capable of accurately and thoroughly mixing the catalyst and resin at the moment of atomization on an automatic basis. Atlas Copco have worked on this problem for the last three years, in conjunction with various resin and paint manufacturers, and have now produced a unit, claimed to be the only one of its type on the market, that will accurately meter the resin and catalyst, thoroughly mix them in their liquid form before atomization and finally atomize the mixture in an even spray pattern.

The Atlas catalyst equipment consists of the D 4 A dosing unit, the Ecco 30 D catalyst spray gun, a standard pressure container for the resins or lacquers and a polythene gravity bucket for the catalyst. The catalyst cylinder and piston are made from solid Teflon and the nipples, washers, etc., are also manufactured from Teflon and other materials that are not affected by hydrochloric acid.

The D 4 A dosing unit consists of three cylinders, one for catalyst, one for air and one for resin or paint (see Fig. 3).

From the pressure container D (Fig. 2) the resin line runs into the dosing unit E through an automatic valve to the inlet side of the resin cylinder and from the outlet side

*Fig. 1.—Two-gun hot spray unit.*


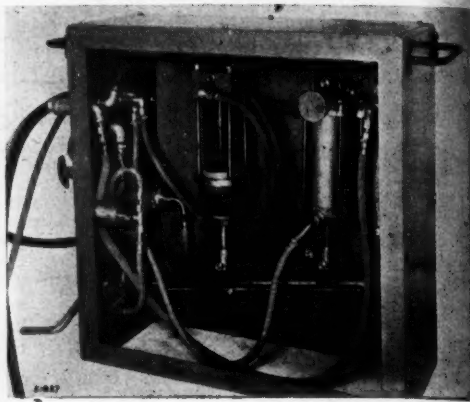

*Fig. 2 (left).—Catalyst spray equipment.*
*A.—Spray gun B.—Hook valve C.—Catalyst gravity bucket. D.—Resin pressure container. E.—Dosing unit*
*Fig. 3 (above).—Internal view of dosing unit showing air, resin and catalyst cylinders, pistons, fi ed and moving bars and automatic cut-off valves in resin and catalyst lines.*

of the resin cylinder to the normal inlet of the spray gun A. The catalyst circuit is from the polythene gravity bucket C or polythene-lined pressure container, to the dosing unit through an automatic valve to the inlet of the catalyst cylinder and again from the outlet to the near of the catalyst spray gun. Two automatic cut-off valves in the catalyst and resin circuits are built into the dosing unit.

From the main air supply a high-pressure air line runs from the air transformer direct to the inlet of the hook valve B, and then on to the inlet of the dosing unit and is by-passed at full pressure to the two air valves on the catalyst and resin lines and finally reaches a reducing valve where the main air line pressure can be reduced before passing on to the under side of the air cylinder in the dosing unit. From the reduced side of the air transformer the normal air line is taken to the spray gun for controlling the atomization pressure, according to the materials involved.

When the hook valve is closed there is no air flow to the dosing unit and the pressure in the pressure container forces the resin through the open valve into the resin cylinder. As the resin is filled the piston travels downwards and automatically returns the pair pistom and catalyst piston to the bottom of their normal stroke.

When the gun is taken off the hook the main air-line pressure immediately transmits itself to the valve on the catalyst and resin lines, automatically shutting off the supply of resin and catalyst to the unit and leaving a sealed circuit and resin and catalyst in the volumetric proportions pre-determined by the position of the catalyst cylinder.

At the same time there is reduced pressure on the lower side of the air cylinder and it is this pressure that acts as a motive power for forcing both the catalyst and resin to the spray gun.

When the trigger is pressed both catalyst and resin are discharged through the spray gun in guaranteed volumetric proportions, which will be maintained irrespective of the diameter or length of hoses between the unit and the gun.

The spray gun is generally the same as the standard Ecco guns with the exception that it has a hollow needle through which the catalyst flows and a catalyst valve which is fixed to the backhead of the spray gun.